300-95-1/v.3

DCA CIRCULAR 300-95-1

DEFENSE COMMUNICATIONS AGENCY

PLANNER'S GUIDE TO FACILITIES LAYOUT AND DESIGN FOR THE DEFENSE COMMUNICATIONS SYSTEM PHYSICAL PLANT

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VOLUME 3

EXAMPLE FACILITY CONSTRUCTION PROJECTS

D5.104:

DEPARTMENT OF DEFENSE UNITED STATES OF AMERICA

DEFENSE COMMUNICATIONS AGENCY
WASHINGTON, D. C. 20305

DCA CIRCULAR 300-95-1

29 July 1985

DCA FACILITIES

A Planner's Guide to Facilities Layout and Design for the Defense Communications System Physical Plant

1. Purpose. This Circular provides planning information, guidance, and criteria for the development of facility renovation, expansion, alteration, or new construction projects planned for the worldwide DCS physical plant.

2. Applicability. This Circular applies to Headquarters, DCA; DCA field activities; and military departments responsible for the planning and acquisition of DCS facilities.

3. Contents. To facilitate the use, updating, and expansion of the material covered, the Circular has been organized into three general divisions.

a. Volumes 1a and 1b provide the bulk of the information neccesary to plan specific DCS facility types. All of the theoretically ideal data which needs to be considered at any of the stages of project development is contained in these first two volumes.

b. Volume 2 contains generic information which may additionally apply to specific facilities, depending on their location and importance within the DCS.

c. Volume 3 provides a series of case studies to demonstrate ways of applying the "ideal" guidance contained in the first three volumes with the practical limitations of the world in which the DCS must plan and operate.

4. Document Improvement. This is intended to be a living document, one which will mature with the evolution of the DCS. To accomplish this goal, comments or suggestions for improvement of the contents are encouraged, and should be directed to the Defense Communications Agency, ATTN: Code B212, Washington, D. C. 20305.

FOR THE DIRECTOR:

DARLENE K. BREWER
Colonel, USAF
Chief of Staff

OPR: B212
DISTRIBUTION: Special

FOREWORD

This investigation was performed by the Facility Systems Division (FS), of the U.S. Army Construction Engineering Research Laboratory (USA-CERL), Interstate Research Park, P.O. Box 4005, Champaign, IL 61820, for the Defense Communication Agency under Order No. HC 1001-2-40152.

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INTRODUCTION

1 Purpose of This Document

The Military Departments operate Defense Communication System (DCS) facilities throughout the United States and the free world. These facilities must provide a high level of mission responsiveness which will enhance the specific military activity efforts of the service personnel. Also, since the DCS requirements and communication equipment are constantly evolving, a great deal of facility flexibility is required.

DCA/DCEC desired to implement an optimum work station and facility layout design handbook to assist planning, programming and designing personnel to improve the environmental conditions for the users of all DCS facilities. To this end, CERL was requested to survey, evaluate and design prototype optimum work stations and total facility layouts for all personnel and equipment requirements. The objective of this effort was to develop optimum prototype space utilization and habitability designs for all DCS facility types. A research plan was started to: 1) determine all generic communication areas and space requirements, 2) analyze the mission responsiveness issues (efficiency, privacy, security, etc.) for the various work stations, 3) design an optimum layout plan for each space type, and 4) develop a planning, programming and design document to assist in the development of all future projects. This information is in Volumes 1A, 1B, and 2.

During the process of developing information for the various facility types of the DCS, over 30 site visits were made to existing DCS facilities. These site visits were made to obtain the information necessary to allow the current users of DCS facilities to apply their extensive experience knowledge to the improvement of both new construction and retrofits of current facilities. The site visits were also carried out to allow the CERL researchers to evaluate what possible retrofits could occur at each of those sites that could immediately improve the facilities to bring them to the quality of mission responsiveness for which the DCS documents were intended. The example case studies that were created during the site visits are included in this volume to assist those that use the generic information documents of volumes 1A, 1B and 2 when they develop new construction or retrofit projects. Thus, the purpose of this document is to provide realistic examples for the awareness of all those needing to use the three generic information volumes.

During the site visits, a portion of the time was spent in specifically assessing the mission responsiveness and quality of life of the existing facility in relation to the DCS requirements. For each of the facilities an evaluation was made that would indicate whether or not an improvement could be categorized as a functional improvement dealing with the DCS mission operational activities or whether it was a improvement dealing with the DCS requirements for system survivability. The projects shown in this document include a mixture of three different types of case study examples. First, a set dealing with operational improvements for the DCS mission. Second, a group dealing with the survivability of the DCS mission. Third, examples dealing with new construction opportunities that are available for a limited amount of future DCS facilities. It should be recognized that most of the construction funding for DCS facilities is used for retrofits of existing sites throughout the world. For this reason, the majority of the example case studies are retrofits rather than new construction projects. Currently retrofits usually result in a facility losing much of the quality of life conditions and mission responsiveness conditions. The intention of the drawings and the text describing these case study examples is to indicate how the operational effectiveness and the quality of life for service personnel can actually be improved through retrofits rather than diminished. Volume 3 also includes any research reports that DCA considers relevant to those making planning and design decisions about DCS construction projects. The initial report included concerns semi-hardened contingency communication shelters. It is an example of a future facility type that may be a viable option for the reconstitution/reconfiguration of the DCS in wartime. Additional project case studies and relevant research reports are to be periodically added to Volume 3.

2 Organization of the Information

The information about the examples is focused on the kinds of knowledge that are required to accomplish a construction project. For example, information dealing with the 1391 form is indicated for all new construction projects. The 1391 requirements are the basis for the funding and scope justification that initially establishes a DCS project in a military construction program. It becomes extremely important for the project to be completely documented by the time the 1391 form is submitted if the project is going to be successful. The examples shown for the new construction projects, one for each of the MILDEPs, indicates the kinds of drawings that are necessary to accompany 1391s. The facility layout drawings should give the level of knowledge that indicates the layout of the furnishings and equipment within the various parts of a facility. Now, 1391 plan drawings indicate only an arrangement of rectangular spaces that are to become a building. It is only through understanding what is internally happening within the spaces that decision-makers can apply the judgment necessary to realize that the scope and justification information on the 1391 is appropriate. Many examples can be cited that show how underfunding creates major problems for the final acceptability of the mission responsiveness of DCS facilities. Currently, projects are shown on 1391 submittals in an outline form as an arrangement of rooms where different activities will happen. The case study examples show now more information can be available on plan drawings at this critical decision making period.

For the retrofit projects, two different types are used for examples. Several show how improvements can be made in existing facilities with no additional building construction. These projects are possible by rearranging equipment and operational spaces within buildings that now have space available due to the size reduction of electronic equipment as we shift from analog to digital equipment. Other retrofit case studies show what improvements could happen when an addition to an existing building is constructed. By rearranging certain parts of the existing facility, the total building can be improved--rather than ignoring the existing spaces and only addressing the new areas. It was determined that the examples selected for inclusion in this volume be representative of projects now being developed in the MILDEPs. Also, selection was based on their applicability for explaining where information can be found in Volumes 1A, 1B, and 2. The case studies should not be considered as examples to be replicated. Rather, as examples that can be used to show how the generic information can be applied to specific facility projects. In each case, the service personnel played a significant role in developing the requirements for the modifications. The personnel approached their responsibilities with high enthusiasm once they were made aware of the possibilities that the generic information provided. Each individual had their own experience to contribute to the project. This knowledge through experience was actually released as a creative input by having the generic information of Volume 1A, 1B, and 2 as a frame of reference to which they could respond. It allowed each individual's knowledge to be "triggered" by the awareness that others have met the same conditions and have used other ways of solving the same problems. Each project solution shows how a building modification can have an enabling effect (rather than a limiting effect) in accomplishing the DCS mission.

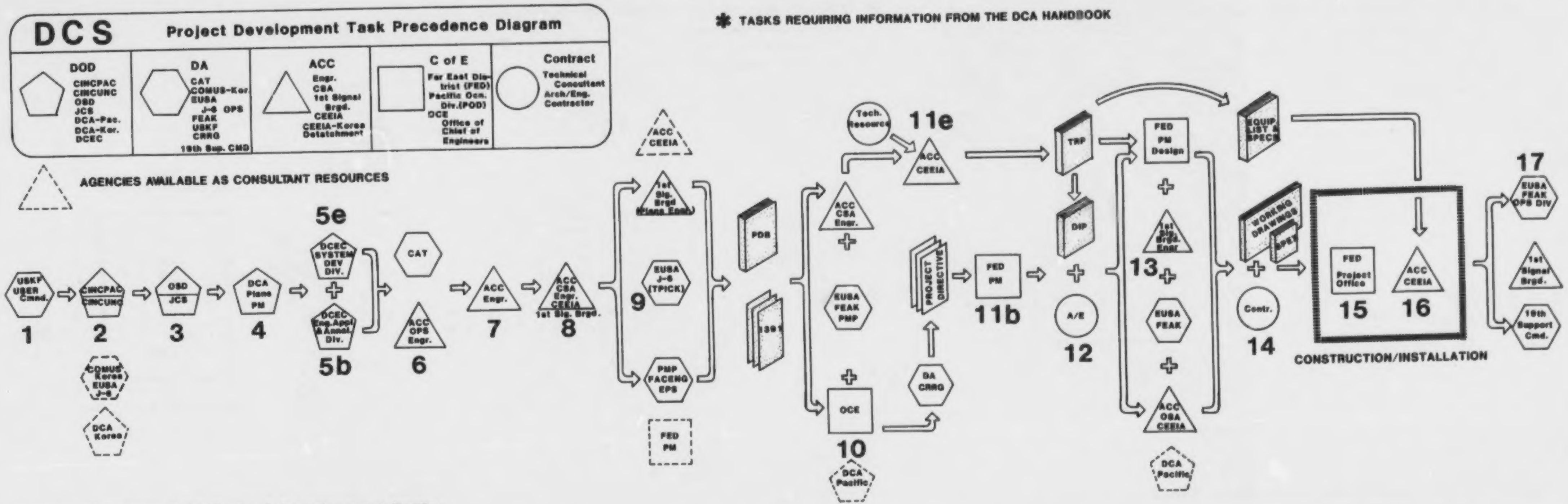
The operational improvement retrofits and the new construction example projects are all described in terms of the "Building Design Principles" that are presented for each of the DCS generic facility types. (See SC16, LS16, TS15 or HF14 in Volume 1A or VO13, ME24 in Volume 1B.) Thus, users of this volume are referenced to the generic operational improvement information in Volumes 1A and 1B via the universal building design principles that should be considered as an important part of the planning and design decisions of any communication facility project. The survivability improvement example projects are all described in terms of the generic information contained in the SB8-Survivability Section of Volume 2. Users of this volume are referenced directly to the generic survivability feature information contained in Volume 2; i.e., revetment, camouflage, etc.

3 Military Construction Design Decision Makers that Use of Information from Volumes 1A, 1B, and 2.

The generic information in Volumes 1A, 1B, and 2 is intended for the use of all persons developing the full range of planning, programming, and design decisions for DCS construction projects. (The case studies in Volume 3 however, apply mostly to persons making specific decisions at the period in the project development that is related to the design solution.) The three different military departments all require an approximately five year facility delivery process for new construction work. Input for retrofit projects usually requires a shortened list of participants over a shorter time period. New construction projects start with a Requirement of Capability (ROC) that needs to be justified. The ROC justification can sometimes be modified or at times eliminated for retrofit projects. The following three diagrams indicate the complete range of information transfer tasks involved in DCS construction projects when all participants are required. The diagrams, one each for Army, Navy, and Air Force, show there are approximately 15 different tasks that require information transfer to accomplish a project. The various tasks are carried out by several different organizations. Several within the military departments and then several more dealing with the construction industry, ending with usually a commercial sector architecture/engineering firm to do the final contract documents. The diagrams indicate the extensive amount of information that is required to turn a capability into a DCS facility. They further illustrate the importance of making all project information documents as comprehensive as possible so that the design decisions are not needlessly constrained. It can be observed that if the information for steps 5 and 7 is incomplete, the necessary decision-making of steps 9, 11, and 13 would be greatly impacted. This is what we have found happening in many current projects. Many times the individuals doing design review in task 13 have for the first time become aware of what the building is going to provide internally (inside the spaces), yet earlier decision makers needed to have had that information back at tasks 5, 7 and especially task 9 when the project was being funded. Each of the tasks in these diagrams is a decision-making situation where all individuals involved must apply their own "specialized" input. Most individuals involved in construction projects are making their input from a distinctly specialist point of view; i.e. an electronics engineer, a structural engineer, etc. The information in volumes 1A, 1B, and 2 has been developed to provide a comprehensive frame-of-reference to which each specialist can relate. Thus, they can feel that their input is going to be applied within the context of a total frame-of-reference. They can see how their special input relates to the total from the very beginning. Many participants in military construction projects are not aware of the total process required. By understanding the relationships of the information transfer tasks and the various other participants, each can feel their participation is significant and will be important for the final success of the project. The various participants in a construction project need to be aware of their own responsibility to view the facility in terms of the optimum mission responsiveness and occupant quality-of-life. If their input is limited only to an awareness of specialist information about hardware items of equipment or concerns for waterproofing and structural stability, their collective decisions will not contribute to a mission responsive and optimum quality-of-life facility. If, however, the decision-makers base their input upon the operational mission activities and the optimum environmental conditions for occupants, then their collected contributions will probably result in a more successful facility.

1	PROJECT PLAN INITIATION	Develop user requirements for a communication capability based upon defense pacts, treaties, and other negotiations. Send to CINCPAC and CINCUNC.
2	PROJECT PLAN APPROVAL	Approve Plan request, and transmit as a Memo of Policy (MOP).
3	5 YEAR CONSTRUCTION PROGRAM	Approve the inclusion of these communication requirements into a 5-year Program Plan.
4	5 YEAR CONSTRUCTION PROGRAM	DCS plan program managers integrate communication requirements into the DCS 5-year plan, in terms of the basic military mission of a facility.
5	PROJECT INFORMATION -- A	DCEC Equipment Development Div. & Eng. Applications and Analysis Div. develop equipment (e) and building (b) information. ✱
6	PROJECT INFORMATION --B	ACC, OPS and Program Group develop final Plan/ Program documentation to initiate the Communication Requirements information.
7	PROJECT SCOPE	ACC/CSA establish the project definition as to scope, site location, new construction vs. retrofit. etc. ✱
8	PROJECT SITE INFORMATION	ACC groups complete Site Surveys to document the existing conditions that become the "givens" for the Project PDB and 1391 documents.
9	DEFINE PROJECT REQUIREMENTS	Develop Functional Requirements (PDB) & 1391 with the assistance of all agencies indicated. ✱
10	SELECT CONSTRUCTION PROGRAM	Determine MILCON vs. CDIP (Combined Defense Improvement Project) funding. DA/CRRG promulgates Project Directive.
11	DESIGN CRITERIA	Develop Design Information Package for the building (b) and Equipment Installation Package (EIP) for the communications equipment. ✱
12	PROJECT DESIGN	Develop facility and equipment designs preliminary concept final ✱
13	DESIGN REVIEW & APPROVAL	Monitor material and systems selection as Contract Documents are being developed. ✱
14	BID LETTING	
15	CONSTRUCTION SURVEILLANCE	Observe building construction, with an emphasis on the optimum integration of building components and systems.
16	EQUIPMENT INSTALLATION	Monitor communication equipment installation and check out.
17	OPERATIONS MAINTENANCE	Evaluate facility and equipment configuration for continued mission responsiveness and real property accountability. ✱

PLAN PROJECT — PROGRAM PROJECT — PROJECT INFORMATION — PROJECT DESIGN — PROJECT CONSTRUCTION — OCCUPANCY


DCS
Project Development Task Precedence Diagram
DOD
CINCPAC
CINCUNC
OSD
JCS
DCA-Pac.
DCA-Kor.
DCEC
DA
CAT
COMUS-Kor.
EUSA
J-6 OPS
FEAK
USKF
CRRG
19th Sup. CMD
ACC
Engr.
CSA
1st Signal Brgd.
CEEIA
CEEIA-Korea Detatchment
C of E
Far East District (FED)
Pacific Ocn. Div.(POD)
OCE
Office of Chief of Engineers
Contract
Technical Consultant
Arch/Eng. Contractor
AGENCIES AVAILABLE AS CONSULTANT RESOURCES
USKF USER Cmnd.
1
CINCPAC
CINCUNC
2
COMUS Korea EUSA J-6
DCA Korea
OSD
JCS
3
DCA Plans PM
4
5e
DCEC SYSTEM DEV DIV.
DCEC Eng.Appl & Anal. Div.
5b
CAT
ACC OPS Engr.
6
ACC Engr.
7
ACC CSA Engr. CEEIA
1st Sig. Brgd.
8
ACC CEEIA
1st Sig. Brgd (Plans Engr.)
EUSA J-6 (TPICK)
9
PMP FACENG EPS
FED PM
PDB
1391
ACC CSA Engr.
EUSA FEAK PMP
OCE
10
DCA Pacific
Tech. Resource
11e
ACC CEEIA
PROJECT DIRECTIVE
DA CRRG
FED PM
11b
TRP
DIP
A/E
12
FED PM Design
1st Sig. Brgd. Engr
13
EUSA FEAK
ACC OSA CEEIA
DCA Pacific
EQUIP LIST & SPECS
WORKING DRAWINGS
SPEX
Contr.
14
FED Project Office
15
ACC CEEIA
16
CONSTRUCTION/INSTALLATION
17
EUSA FEAK OPS DIV
1st Signal Brgd.
19th Support Cmd.

✱ TASKS REQUIRING INFORMATION FROM THE DCA HANDBOOK

Typical U.S. Army DCS Project Development Tasks

READEX FICHE

1 PROJECT PLAN INITIATION	Establish the requirement for a communication capability. Develop a ROC statement with station input.
2 TELCOR DEVELOPMENT	Define implications of the ROC on the station mission or modification to the mission.
3 PROJECT FACILITY REQUIREMENTS	Match ROC requirements with existing comm sta assets. Identify deficiencies on DD 11000/4 and submit. ✱
4 DD 11000 VALIDATION	Verify and approve DD 11000/4 submittals and forward into POM process.
5 POM PROCESS	Assign project to a POM year based on the determination of prioritizing of all relevant construction projects.
6 DETERMINE PROJECT TYPE	Identify electronic/communication requirements that need BESEP documentation.
7 DEVELOP BESEP	Prepare Base Electronic System Engineering Plan (BESEP) document for basis of engineering requirements. ✱
8 DEFINE PROJECT REQUIREMENTS	Prepare a facility study as a statement of requirements justification that is submitted as a DD1391. ✱
9 VALIDATE 1391	Validate 1391 justification statements for project needs leading toward and authorization of design services.
10 DESIGN CRITERIA	Develop design information package for both the building and the equipment procurement. Contract with project A/E firm for design services. ✱
11 PROJECT DESIGN	Develop facility and equipment designs and contract documents. Allow for 3 design reviews: preliminary, concept and final. ✱
12 BUDGET SUBMITTAL & APPROVAL	Reviews and approves projects for final funding approval via Congressional hearings.
13 PROJECT FUNDING	Reviews and submits project budget for OSD review and approval.
14 AUTHORIZE CONSTRUCTION	Review funding approval to authorize funding of construction Final Review of Contract documents for bidding.
15 BID LETTING	
16 CONSTRUCTION SURVEILLANCE & EQUIPMENT INSTALLATION	Observe project completion leading to acceptance of the facility from the contractors.
17 OPERATIONS/MAINTENANCE	Accepts facility and systems for the MILDEP. Manages and continuously evaluates the facility and systems to accomplish the assigned mission. ✱

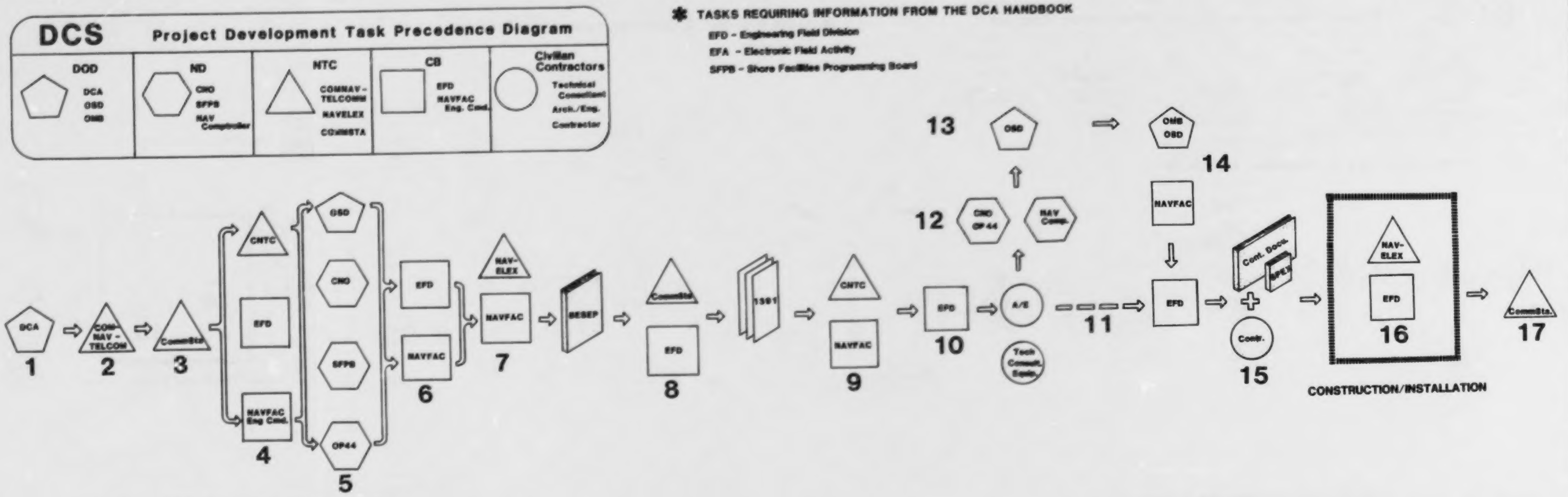
PLAN PROJECT (1–4) · PROGRAM PROJECT (5–6) · PROJECT INFORMATION (7–10) · PROJECT DESIGN (11–14) · PROJECT CONSTRUCTION (16) · OCCUPANCY (17)

✱ TASKS REQUIRING INFORMATION FROM THE DCA HANDBOOK

EFD - Engineering Field Division

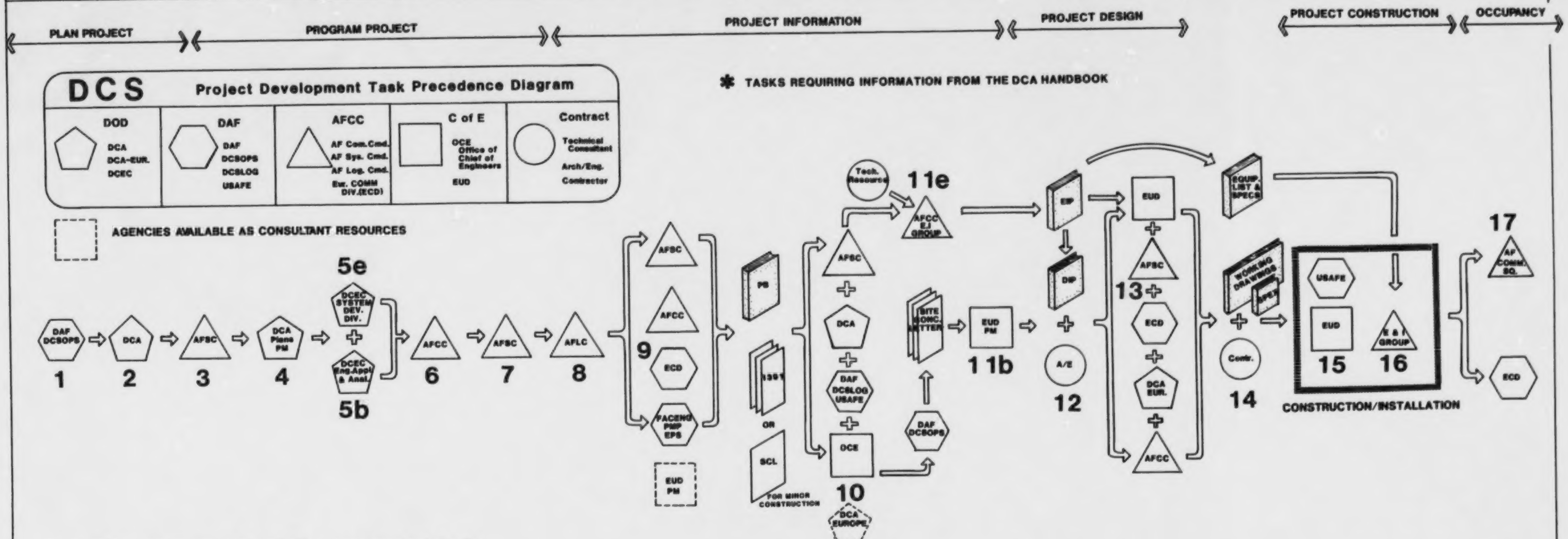
EFA - Electronic Field Activity

SFPB - Shore Facilities Programming Board


DCS
Project Development Task Precedence Diagram
DOD
DCA
OSD
OMB
ND
CNO
SFPB
NAV Comptroller
NTC
COMNAV-TELCOMM
NAVELEX
COMMSTA
CB
EFD
NAVFAC Eng. Cmd.
Civilian Contractors
Technical Consultant
Arch./Eng.
Contractor
DCA
COM-NAV-TELCOM
CommSta
CNTC
EFD
NAVFAC Eng Cmd.
OSD
CNO
SFPB
OP44
EFD
NAVFAC
NAV-ELEX
NAVFAC
BESEP
CommSta
EFD
1391
CNTC
NAVFAC
EFD
A/E
Tech Consult. Equip.
CNO OP44
NAV Comp.
OSD
OMB OSD
NAVFAC
EFD
Cont. Docs.
SPEX
Contr.
NAV-ELEX
EFD
CONSTRUCTION/INSTALLATION
CommSta.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

Typical U.S. Navy DCS Project Development Tasks

1	PROJECT PLAN INITIATION	Develop user requirements for a communication capability based upon defense pacts, treaties, and other negotiations.
2	PROJECT PLAN APPROVAL	Approve Plan request, and transmit as a Memo of Policy (MOP).
3	5 YEAR CONSTRUCTION PROGRAM	AFSC puts communication requirements into the 5-year Program Plan.
4	5 YEAR CONSTRUCTION PROGRAM	DCA plan program managers integrate communication requirements into the DCS 5-year plan, in terms of the basic military mission of a facility.
5	PROJECT INFORMATION - - A	DCEC Equipment Development Div. & Eng. Applications and Analysis Div. develop equipment (e) and building (b) information. *
6	PROJECT INFORMATION - - B	AFCC, OPS, and Program Group, develop Final Plan/Program documentation to initiate the Communication Requirements Information.
7	PROJECT SCOPE	AFSC establish the project definition as to scope, site location, new construction vs. retrofit, etc. *
8	PROJECT SITE INFORMATION	AFLC groups complete site surveys to document the "existing conditions" that become the "givens" for the Project book and 1391 documents.
9	DEFINE PROJECT REQUIREMENTS	Develop Project Book and 1391 with the assistance of all agencies indicated. *
10	SELECT CONSTRUCTION PROGRAM	Determine MILCON and develop Site Concurrence Letter (SCL).
11	DESIGN CRITERIA	Develop Design Information Package for the building (b) and Equipment Installation Package (EIP) for the communications equipment. *
12	PROJECT DESIGN	Develop facility and equipment designs preliminary concept final *
13	DESIGN REVIEW & APPROVAL	Monitor material and systems selection as Contract Documents are being developed. *
14	BID LETTING	
15	CONSTRUCTION SURVEILLANCE	Observe building construction, with emphasis on the optimum integration of building components and systems.
16	EQUIPMENT INSTALLATION	Monitor communication equipment installation and check out.
17	OPERATIONS MAINTENANCE	Evaluate facility and equipment configuration for continued mission responsiveness. *


PLAN PROJECT
PROGRAM PROJECT
PROJECT INFORMATION
PROJECT DESIGN
PROJECT CONSTRUCTION
OCCUPANCY
DCS Project Development Task Precedence Diagram
DOD
DCA
DCA-EUR.
DCEC
DAF
DAF
DCSOPS
DCSLOG
USAFE
AFCC
AF Com.Cmd.
AF Sys. Cmd.
AF Log. Cmd.
Eur. COMM DIV.(ECD)
C of E
OCE Office of Chief of Engineers
EUD
Contract
Technical Consultant
Arch/Eng.
Contractor
AGENCIES AVAILABLE AS CONSULTANT RESOURCES
* TASKS REQUIRING INFORMATION FROM THE DCA HANDBOOK
DAF DCSOPS
1
DCA
2
AFSC
3
DCA Plans PM
4
5e
DCEC SYSTEM DEV. DIV.
DCEC Eng.Appl & Anal.
5b
AFCC
6
AFSC
7
AFLC
8
9
AFSC
AFCC
ECD
PACENG PMP EPS
EUD PM
PB
1391
OR
SCL
FOR MINOR CONSTRUCTION
AFSC
DCA
DAF DCSLOG USAFE
OCE
10
DCA EUROPE
Tech. Resource
11e
AFCC EI GROUP
SITE CONC. LETTER
DAF DCSOPS
EUD PM
11b
EIP
DIP
A/E
12
EUD
AFSC
13
ECD
DCA EUR.
AFCC
EQUIP. LIST & SPECS
WORKING DRAWINGS
SPEX
Contr.
14
USAFE
EUD
E & I GROUP
15
16
CONSTRUCTION/INSTALLATION
17
AF COMM. SQ.
ECD

Typical U.S. Air Force DCS Project Development Tasks

DCS FACILITY IMPROVEMENT PROJECTS

(FI)

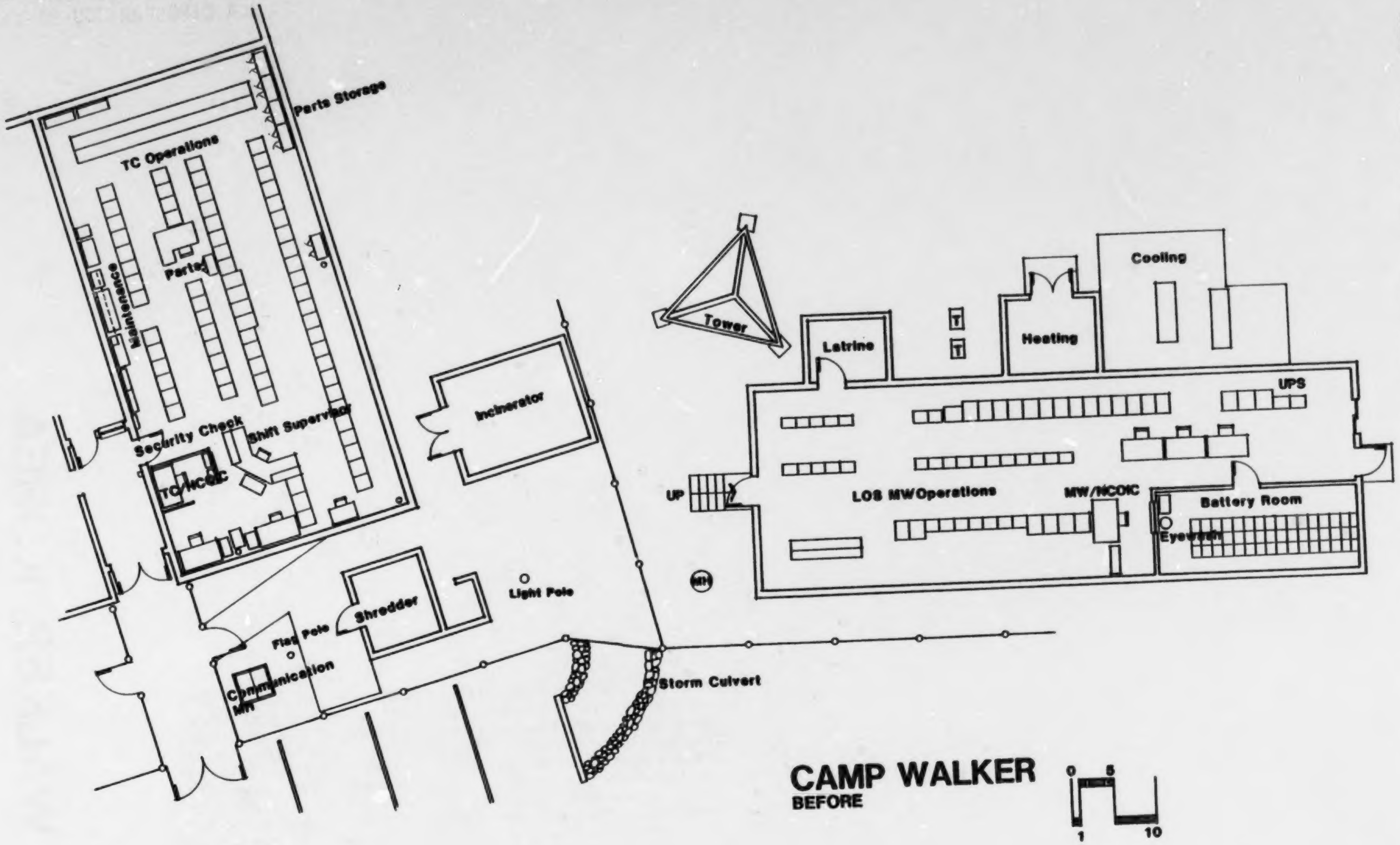
DCS FACILITY IMPROVEMENT PROJECTS **FI**

1 Camp Walker, Korea FI-3
2 Forss, Scotland FI-13
3 Murkle, Scotland FI-27
4 Monte Vergine, Italy FI-37
5 Campbell Barracks, FRG FI-49
6 San Diego, CA FI-57

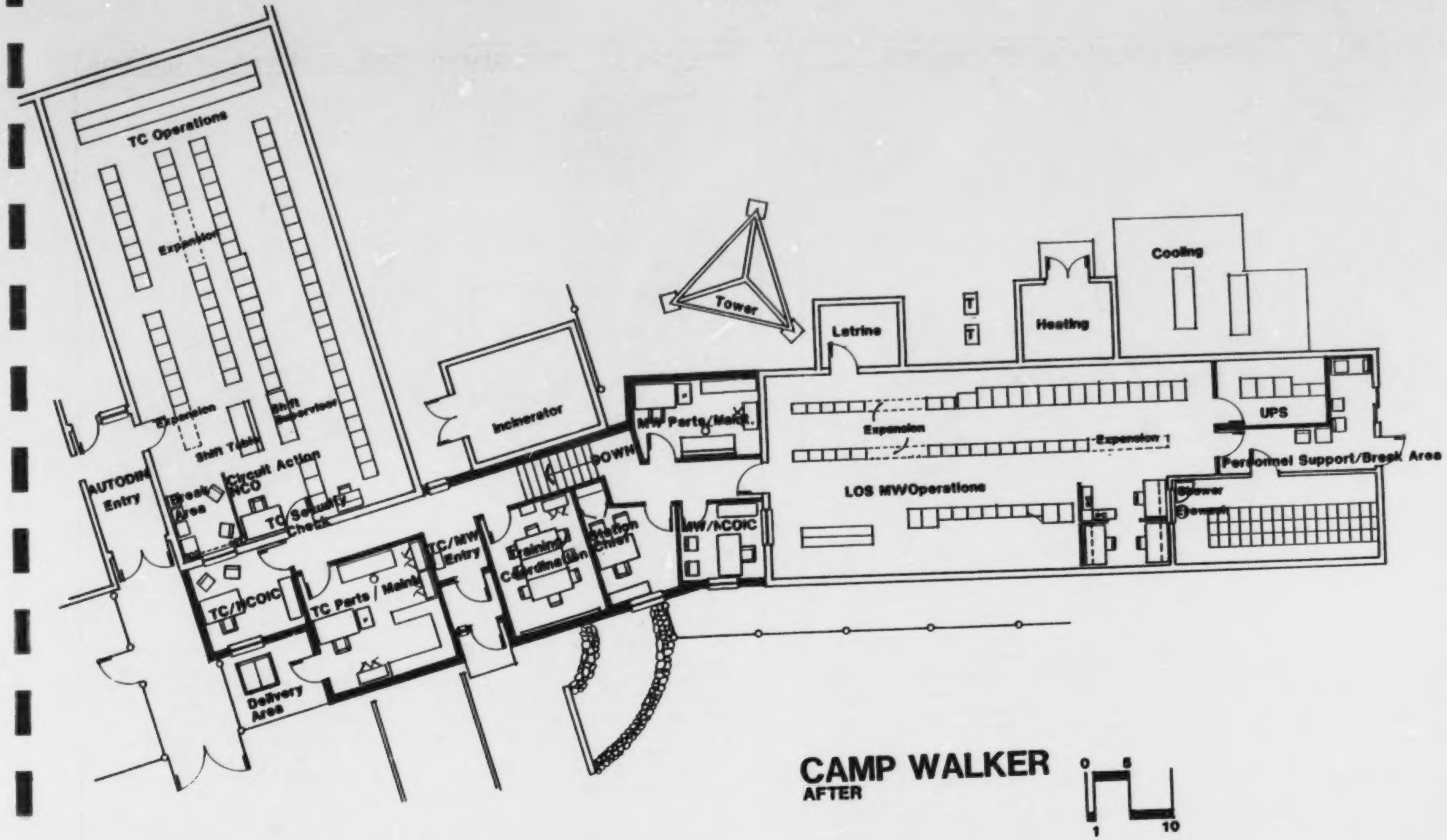
CAMP WALKER, KOREA

GIVEN: This communication station is located in two separate facilities, one housing a line-of-sight (LOS) microwave (MW) operations space and the other housing a technical control (TC) operations space. The site chief is in a third building. The two operations buildings are separated by approximately 60 feet. Each building contains a parts/maintenance area and several administrative workstations. These workbenches and desks are incorporated with the electronic equipment in the operation spaces. Noncommissioned officer in charge (NCOIC) workstations are distributed randomly in the LOS and TC operation spaces.

OBJECTIVE: The retrofit objective is to provide separate, distinct spaces for the two NCOIC and site chief workstations and for the two parts and maintenance activities now occurring in each operation space. Also, a separate training and coordinating space is needed for convenient use by personnel of both the TC and LOS microwave operations.

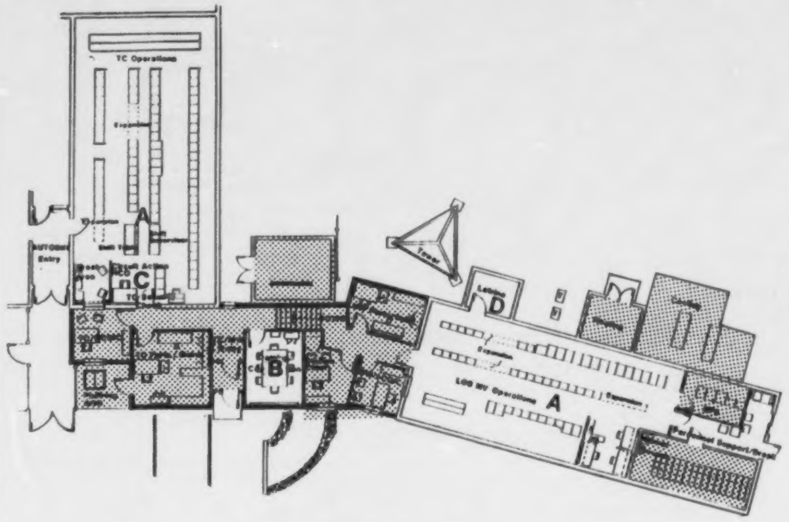

Parts Storage
TC Operations
Parted
Maintenance
Security Check
Shift Supervisor
TC/NCOIC
Incinerator
Shredder
Light Pole
Flag Pole
Communication MH
Storm Culvert
Tower
Latrine
T
T
Heating
Cooling
UPS
UP
MH
LOS MWOperations
MW/NCOIC
Battery Room
Eyewash
0
5
1
10

CAMP WALKER
BEFORE


TC Operations
Expansion
Expansion
Shift Supervisor
Shift Table
Circuit Action NCO
AUTODIN Entry
Break Area
TC Security Check
TC/NCOIC
TC Parts / Maint.
TC/MW Entry
Training/ Coordination
Station Chief
Delivery Area
Incinerator
DOWN
MW Parts/Maint.
MW/NCOIC
Tower
Latrine
T
T
Heating
Cooling
Expansion
Expansion
LOS MW/Operations
UPS
Personnel Support/Break Area
Shower
0
5
1
10

CAMP WALKER
AFTER

guidance 1 Efficiency of Operational Functions



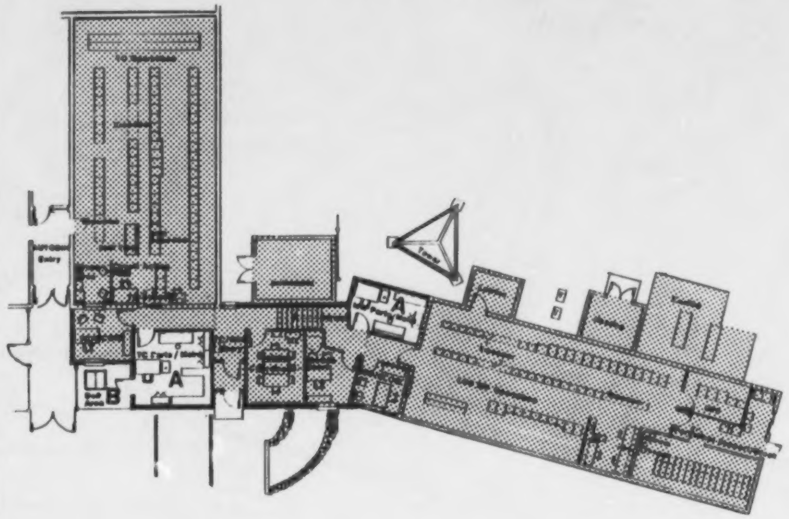
A Equipment is aligned in parallel rows within the operations modules for ease in visual surveillance and to provide direct access to all critical equipment. Multiple consoles are adjacent to each other in the TC so that limited personnel may efficiently monitor them at one central location. Tables for AV training aids are available in the TC and the LOS MW modules so that personnel can train "on-the-job" during regular watch periods.

B To improve the effectiveness of on-the-job personnel training, small groups of four or five can be instructed in the new training room. Some instruction combines text lessons and hands-on training work with the communications equipment; thus, the training room must be close to both operations modules.

C The circuit action noncommissioned officer (NCO) has a close functional relationship to the TC activities and is located adjacent to the TC module.

D Toilet facilities are easily available for personnel in the LOS MW module.

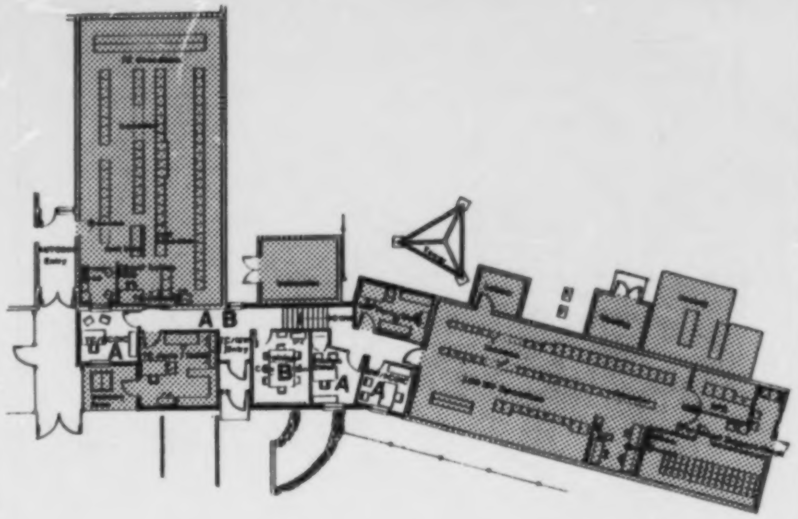
guidance 2 Integration of Parts/Maint Modules with Ops



A Joining the two operation spaces with the parts/maintenance spaces will provide a common link that can be used by all persons needing to access the total communications facility. This will allow both parts/maintenance modules to be well integrated and close to the two operation spaces for optimal personnel efficiency and minimal circulation. The secure door between the operation and maintenance/parts spaces is used only as a fire exit and to move communications equipment in and out. This door should have opening hardware on the secure side only.

B The parts/maintenance modules are located in an organizational context such that equipment can be delivered easily to the total communication facility. A hard-surfaced exterior loading area is required for loading and unloading communication equipment out of the weather.

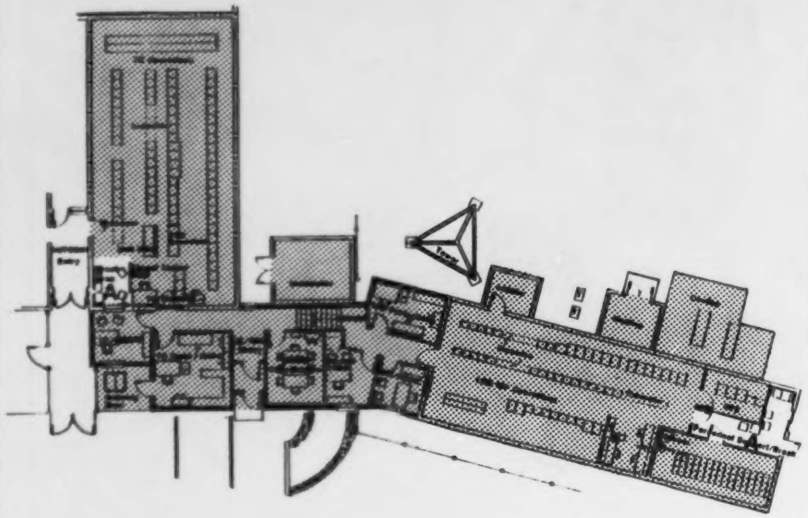
guidance 3 Efficiency and Accessibility of Admin Spaces



A Each NCOIC must have a private space that can be used for the NCOIC's personnel responsibilities. Also, by colocating the station chief in this connecting link, all three major administrative persons will be close together for their mutual responsibilities. Administrative modules are consolidated in the retrofit addition to be easily accessible to the public for minimal circulation and for preventing visitor interference with station operations. The administrative area provides a buffer and transition space between the outdoors and the secure interior spaces. Also, the public corridor in the administrative area contains the military unit logos and other display panels that relate to "esprit de corps" and communication station unit integrity.

B The administration spaces' newly integrated relationship will improve efficiency by minimizing public and administrative circulation and by producing a group adjacency for shared conference, clerk, and waiting areas, instead of having the administrative modules in three separate buildings.

guidance 4 Personnel Support Spaces

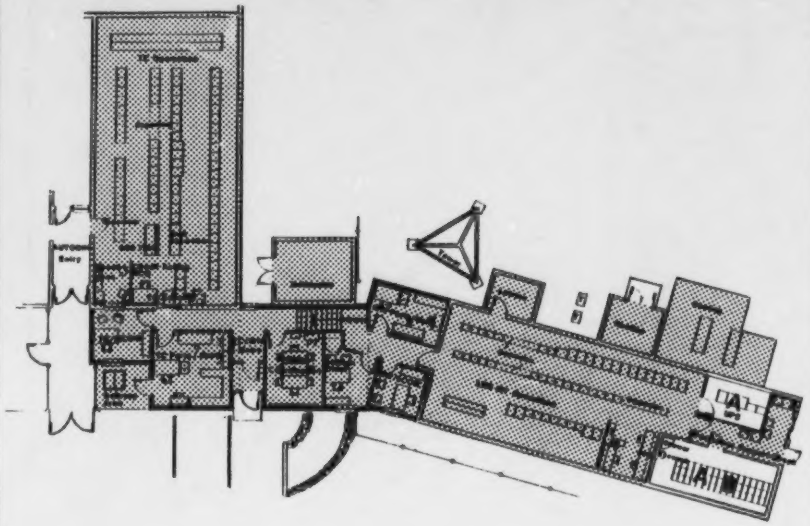


A The intensive activities in communication stations tend to generate personnel mental fatigue. It is therefore necessary to create a change of environment for on-duty personnel as a break from the hard-surface equipment room and work areas. Personnel support/break area modules are adjacent to the TC and LOS MW operations spaces, but isolated acoustically and visually.

Facility Security/Survivability

Since this station is on a military installation, the basic security personnel are in another area rather than being part of the communications staff. Routine security checks, such as checking for personnel identification, are made at the installation gate. Similarly, the defense teams for resisting hostile action consist of other personnel stationed at the installation's security headquarters.

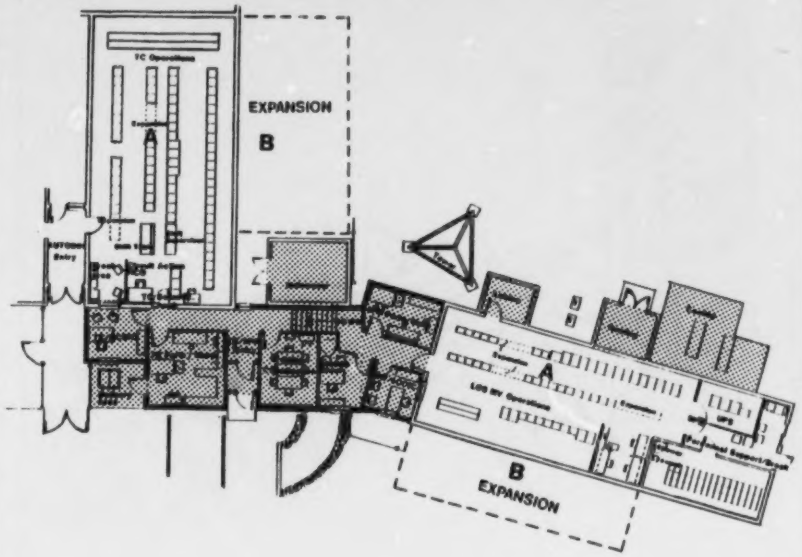
guidance 5 Integration Of Power / UPS Modules



A Modules that comprise the power and UPS gear are close together and well integrated. Adjacency provides economy by minimizing cable lengths and producing personnel efficiency through interaccess relationships.

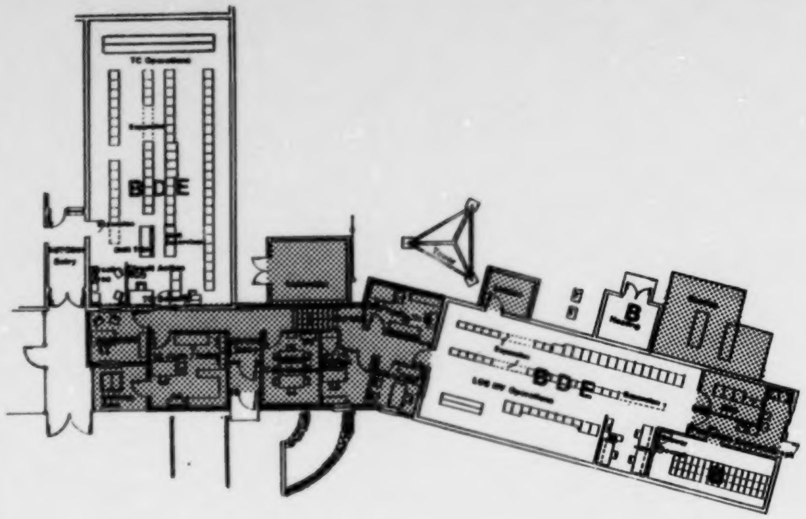
B Direct exterior ventilation of the battery room can be more energy-efficient if the makeup air is conditioned by being ducted through (or coming directly from) the UPS module. The battery room also now contains an emergency eye-wash faucet and a shower.

guidance 6 Facility Expansion



A The communication equipment layout now has several open areas since the maintenance modules were removed to separate rooms in the retrofit addition. This extra space was planned to allow for installation of the equipment needed to handle the maximum projected traffic load. The current equipment layout is such that the station communication equipment can be expanded reasonably without extensively rearranging equipment already installed.

B The TC and LOS MW operations modules are functionally isolated from the other spaces. Due to the increasingly rapid changes in communications technology, future demands on the operations modules' spatial layout can be expected. Spaces for the TC and LOS MW can thus expand to accommodate new equipment and new functions. Support and power spaces probably will not need this same expansion capability.



Occupancy classifications: Business (NFPA); B-2 (UBC)

Hazard of contents classification: Ordinary hazard

Sprinkler protection classification: Ordinary hazard--group 2

Construction classifications/materials for fire protection (See Vol 2, SB3, Fire Protection/Life Safety)

Type II--Fire resistive (UBC) for security/armory spaces

CONSTRUCTION ELEMENT	
Exterior walls....................	4-hr rated construction
Interior bearing walls............	2-hr rated construction
Structural frame..................	2-hr rated construction
Permanent partitions..............	1-hr rated construction
Shaft enclosures..................	2-hr rated construction
Floors............................	2-hr rated construction
Roofs.............................	2-hr rated construction

B Type II--one-hour (UBC) for battery, cryptography (Red and Black),* custodial, generator, operations,* mechanical, and technical control spaces

All construction elements....... 1-hr rated construction

Type II-N (UBC) for the other building spaces

All construction elements....... Noncombustible construction

Building separation

Site-specific information is required. Comply with Vol 2, SB3, Fire Protection/Life Safety.

Interior finishes

See Guidance/Life Safety.

Fire protection systems

Automatic fire suppression:

A water sprinkler system shall be provided throughout the facility.

Halon 1301 or carbon dioxide system shall be provided under all raised floor areas containing nonmetallic sheathed, exposed cables when the space under the raised floor is used as an air plenum.

Automatic notification/alarm:

General alarm activated by the automatic sprinkler system.

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*See Vol 2, SB7, Security, for vault construction requirements that may be more stringent than those imposed by fire protection requirements.

guidance 7

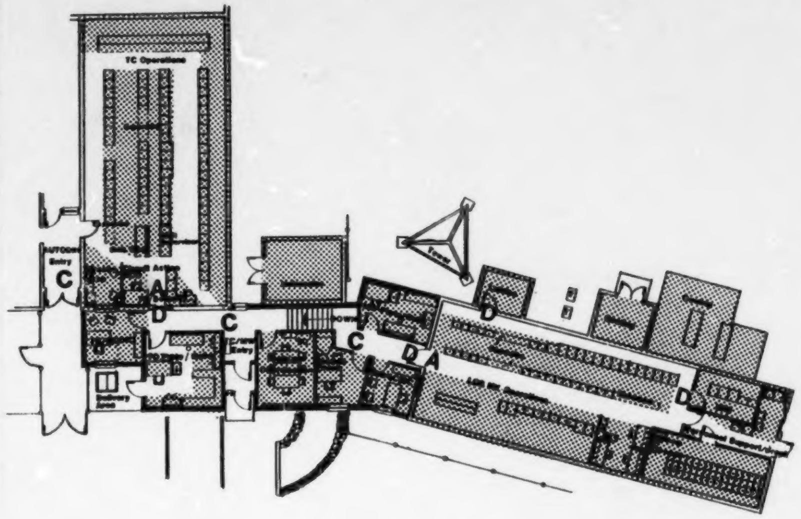
D Local alarm to sound in these spaces only, activated by smoke detectors.

Automatic fire detection

E Smoke detectors to activate local alarms in these spaces only. In rooms containing raised floor areas, smoke detectors shall be located under the raised floor.

guidance

guidance 8 Life Safety



Exit capacities

Corridors: 100 persons per unit of exit width for traveling either direction. The minimum width of any exit access corridor or passageway shall be 44 inches in the clear.
Doors: 100 persons per unit of exit width (a 3-foot door provides 1-1/2 units of exit width, providing exit capacity for 150 persons).

Number of exits

No less than two exits shall be accessible from every part of every floor. A single exit is permitted when the room or area has (1) a total occupant load of less than 100 persons, (2) direct exit to an open area outside the building at the ground level, and (3) a total travel distance on the same level of no more than 100 feet. (If stairs are involved, they shall be no more than 15 feet high and shall be provided with complete enclosures to separate them from all other building parts.

Exit travel distances

Required exits shall be located to allow access without passage through areas subject to locking. No dead-end corridor shall exceed 50 feet. The travel distance to exits shall be no more than 300 feet when the building is protected throughout by an approved automatic sprinkler system.

Arrangement of means of egress

Exit access and travel routes to exits are shown in the plan.
A Exit doors in vaulted areas containing communication system equipment are secured and permit exits only. Exit access routes through vaulted areas from spaces outside these areas are not permitted for security reasons.

Two means of egress shall be provided from higher hazard areas, including mechanical and generator spaces. Exit access from any other space may not pass through mechanical or generator spaces (see exit marking). For security reasons, when mechanical or generator spaces have exit access routes through interior spaces, exit access doors from these spaces, when opened, shall sound an alarm and transmit a signal to the annunciator panel in the security space. Access for normal maintenance in mechanical and generator spaces shall be through the exterior doors.

Interior finishes

C Interior finishes in exit access corridors shall be Class A only.

Interior finishes in the remainder of the building shall be Class A or B only.

guidance 8

Illumination of means of egress

Exits and exit access, including stairs, aisles, corridors, and passageways leading to an exit, shall be illuminated continuously to values no less than 1 footcandle (measured at the floor) while the conditions of occupancy require that a means of egress be available.

Emergency lighting

Emergency lighting shall be provided in windowless buildings for designated aisles, corridors, and passageways leading to an exit. Emergency lighting shall maintain 1 footcandle of illumination throughout the means of egress for 1.5 hours in the event that normal lighting fails.

Marking of means of egress

Exits shall be marked by an approved sign readily visible from any direction of exit access. Sign placement shall be such that no point in the exit access is more than 100 feet from the nearest visible sign.

D Doors located or arranged so they are likely to be mistaken for exits shall be identified by a sign reading "NOT AN EXIT".

guidance

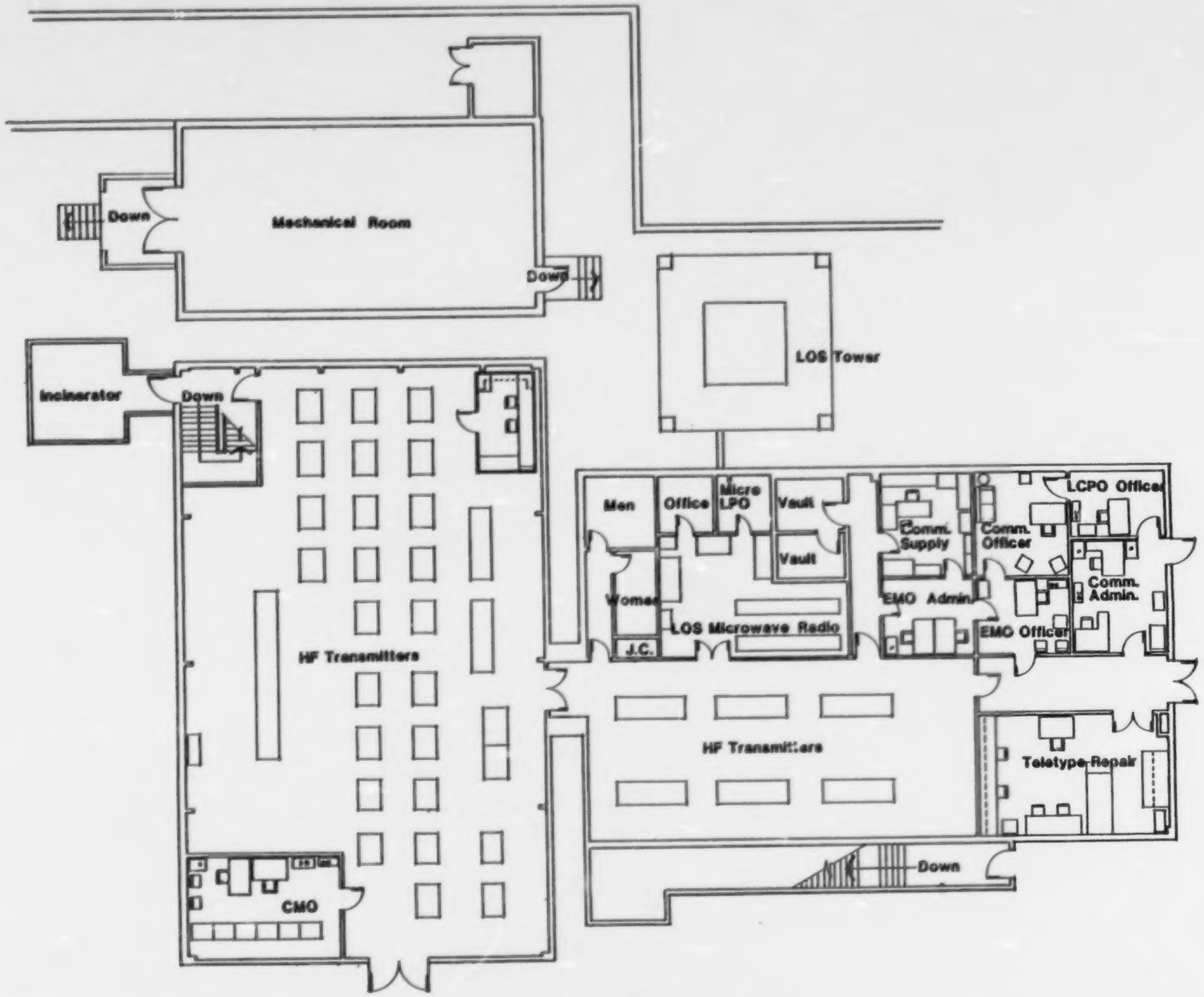
FORSS, SCOTLAND

DCS Building Expansion and Retrofit

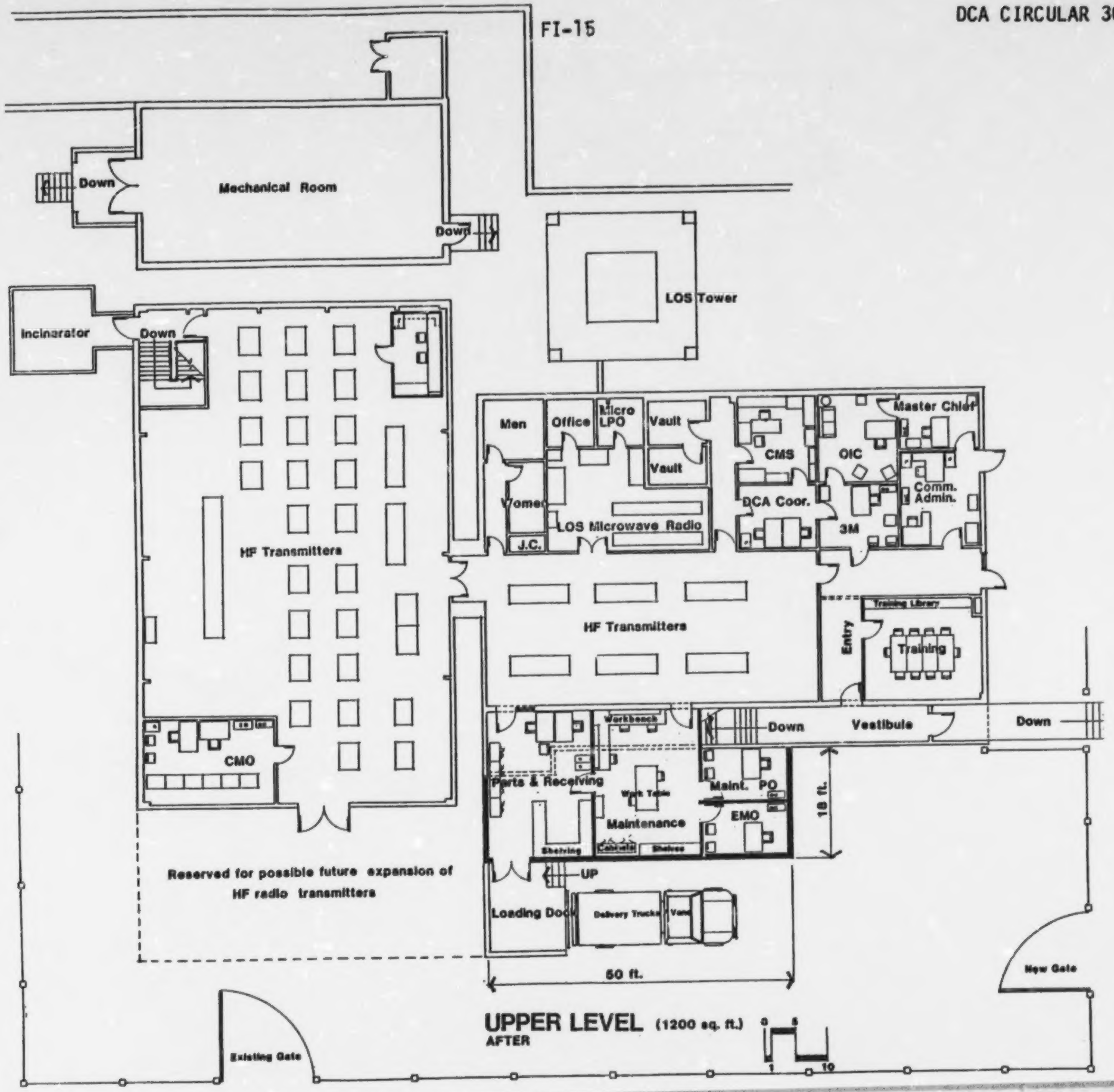
GIVEN: This communication station is a two-story, high-frequency (HF) radio and line-of-sight (LOS) microwave (MW) radio transmitter site with technical control (TC) and message centers. The long-range plan is for a satellite earth terminal to be installed in an existing space on the lower level. The satellite earth terminal is now in an open area that is being used temporarily for the TC administrative area and as an informal training room.

OBJECTIVE: The objective of a retrofit building expansion is to provide distinct, separate spaces for the onsite parts/maintenance areas and a training/coordination area that now form part of the operations spaces.

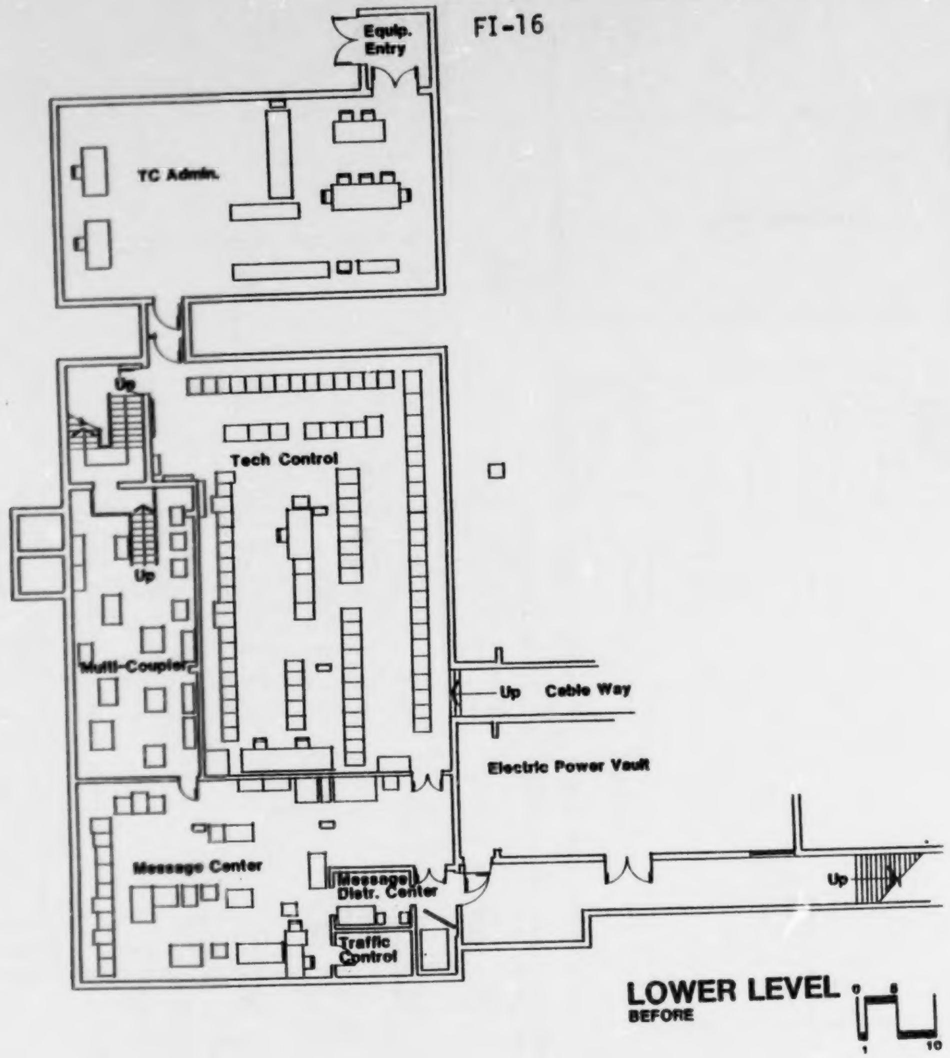
ACTION: These spaces were created in a new building addition. The new building part was located in a way that reserves space for future expansion of additional operations spaces, such as more HF radio transmitter and message center areas.


Down
Mechanical Room
Down
LOS Tower
Incinerator
Down
Men
Office
Micro LPO
Vault
Vault
Comm. Supply
Comm. Officer
LCPO Office
Women
LOS Microwave Radio
EMO Admin.
Comm. Admin.
EMO Officer
J.C.
HF Transmitters
HF Transmitters
Teletype Repair
CMO
Down

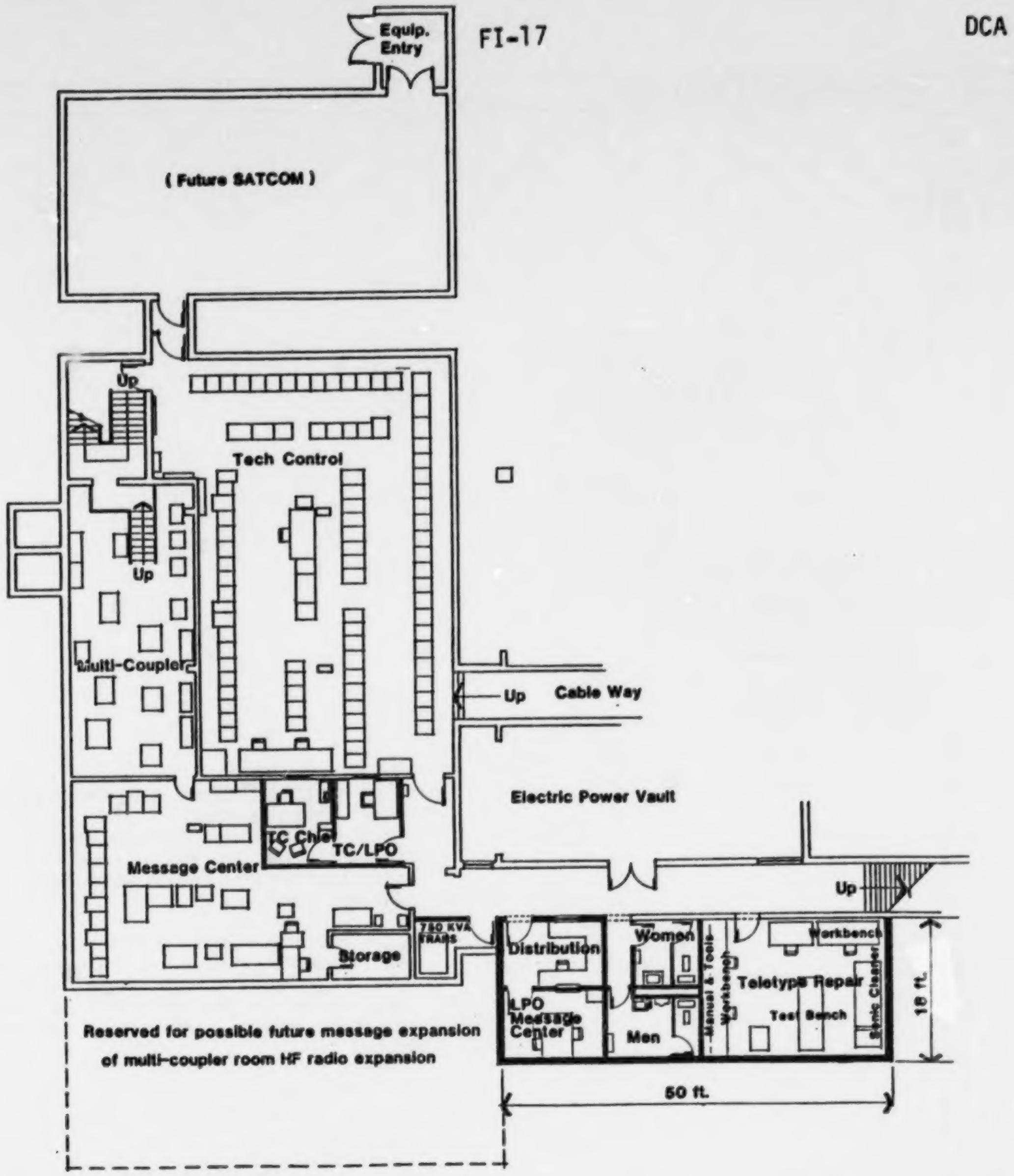
UPPER LEVEL
BEFORE


Mechanical Room
Down
Down
LOS Tower
Incinerator
Down
HF Transmitters
Men
Office
Micro LPO
Vault
Vault
CMS
OIC
Master Chief
Comm. Admin.
Women
LOS Microwave Radio
DCA Coor.
3M
J.C.
HF Transmitters
Training Library
Entry
Training
CMO
Workbench
Parts & Receiving
Work Table
Maintenance
Maint. PO
EMO
Shelving
Cabinets
Shelves
Down
Vestibule
Down
18 ft.
UP
Loading Dock
Delivery Truck
Van
50 ft.
Reserved for possible future expansion of HF radio transmitters
Existing Gate
New Gate
0
5
1
10

UPPER LEVEL (1200 sq. ft.)
AFTER

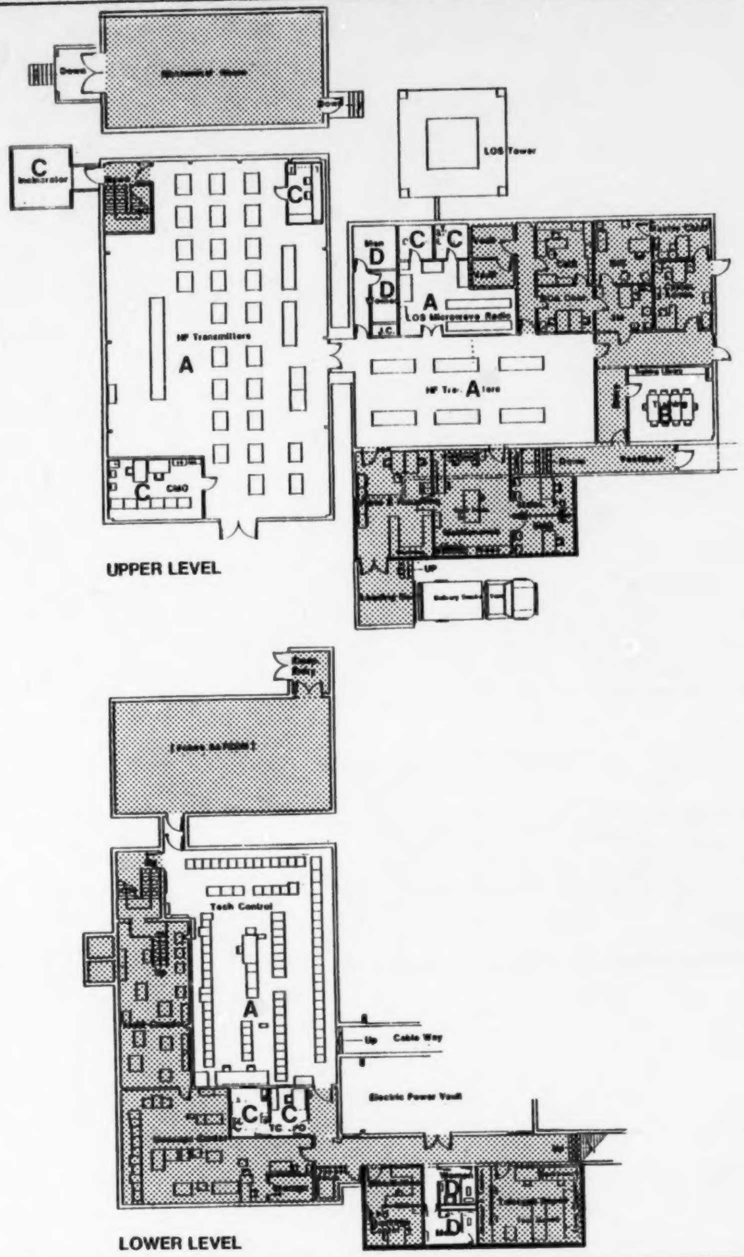

Equip. Entry
TC Admin.
Up
Tech Control
Up
Multi-Coupler
Up
Cable Way
Electric Power Vault
Message Center
Message Distr. Center
Traffic Control
Up
0
5
1
10

LOWER LEVEL
BEFORE


Equip.
Entry
(Future SATCOM)
Up
Tech Control
Up
Multi-Coupler
Up
Cable Way
Electric Power Vault
TC Chief
TC/LPO
Message Center
Up
750 KVA TRANS
Storage
Distribution
Women
Manual & Tools
Workbench
Workbench
Teletype Repair
Test Bench
Sonic Cleaner
18 ft.
LPO
Message
Center
Men
Reserved for possible future message expansion
of multi-coupler room HF radio expansion
50 ft.

LOWER LEVEL (900 sq. ft.)
AFTER

guidance 1 Efficiency of Operational Functions


Down
C
LOS Tower
HF Transmitters
A
C
C
C
D
D
A
LOS Microwave Radio
A
C
UPPER LEVEL
A
Tech Control
Up Cable Way
Electric Power Vault
C
C
D
D
LOWER LEVEL

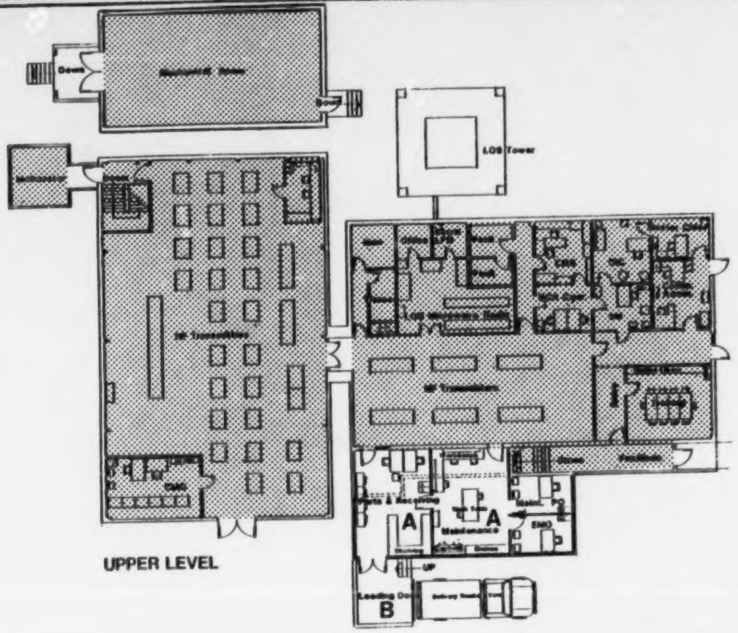
A At this station, the equipment is aligned in parallel rows in each operations module. This allows for efficient visual surveillance and provides direct personnel access to all critical equipment. Tables for audiovisual training aids are available in the operations modules so that personnel can train on-the-job during regular watch periods.

B To improve the effectiveness of personnel training on-the-job, small groups of four or five can be instructed in the training room. For small-group training work with a noncommissioned officer (NCO) instructor and the prototype communications equipment, enlisted personnel require a separate, distinct area where they can concentrate.

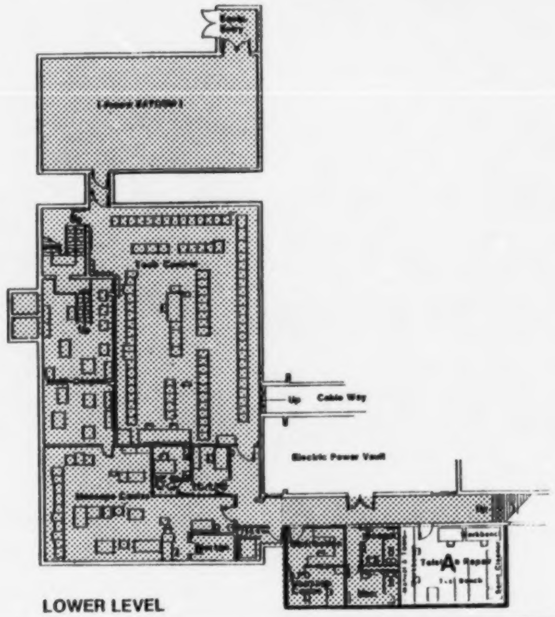
C Additional building spaces that have a close functional relationship to operations activities are located adjacent to the operations modules.

D Toilet facilities are easily available for personnel in the operations module.

guidance 2 Integration of Parts / Maint Modules with Ops



UPPER LEVEL

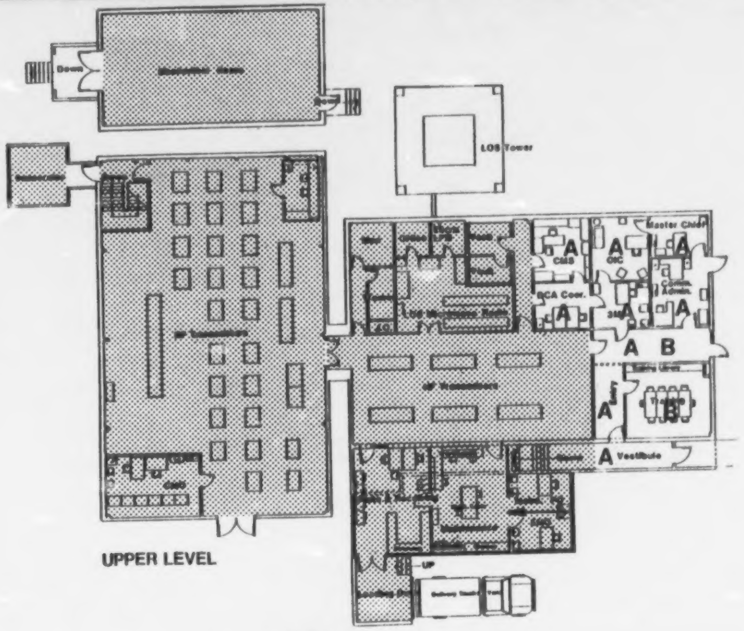


LOWER LEVEL

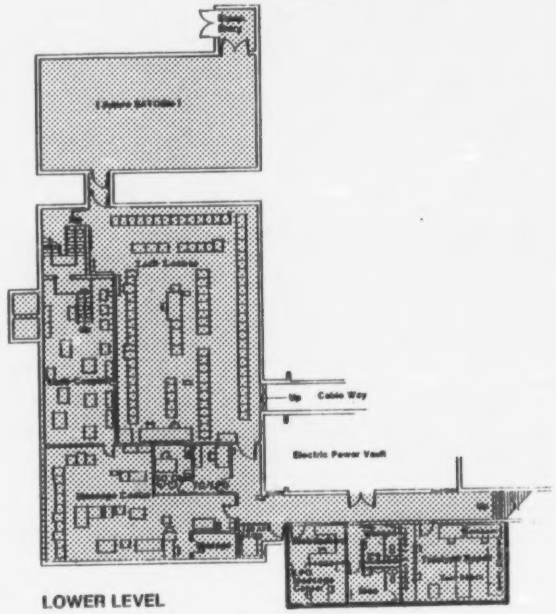
A New parts and maintenance spaces are added for better integration and nearness to the operations spaces to encourage optimal efficiency and minimal circulation. The secure door between the operations and the maintenance/parts spaces is to be used only as a fire exit and to bring communication equipment in and out via the loading dock. This door has opening hardware only on the secure side.

B The parts/receiving space is located within an organizational context such that deliveries can be made directly and securely to the total building at a loading dock. Large communication equipment can be moved in and out more easily using the new loading dock.

guidance 3 Efficiency and Accessibility of Admin Spaces



UPPER LEVEL

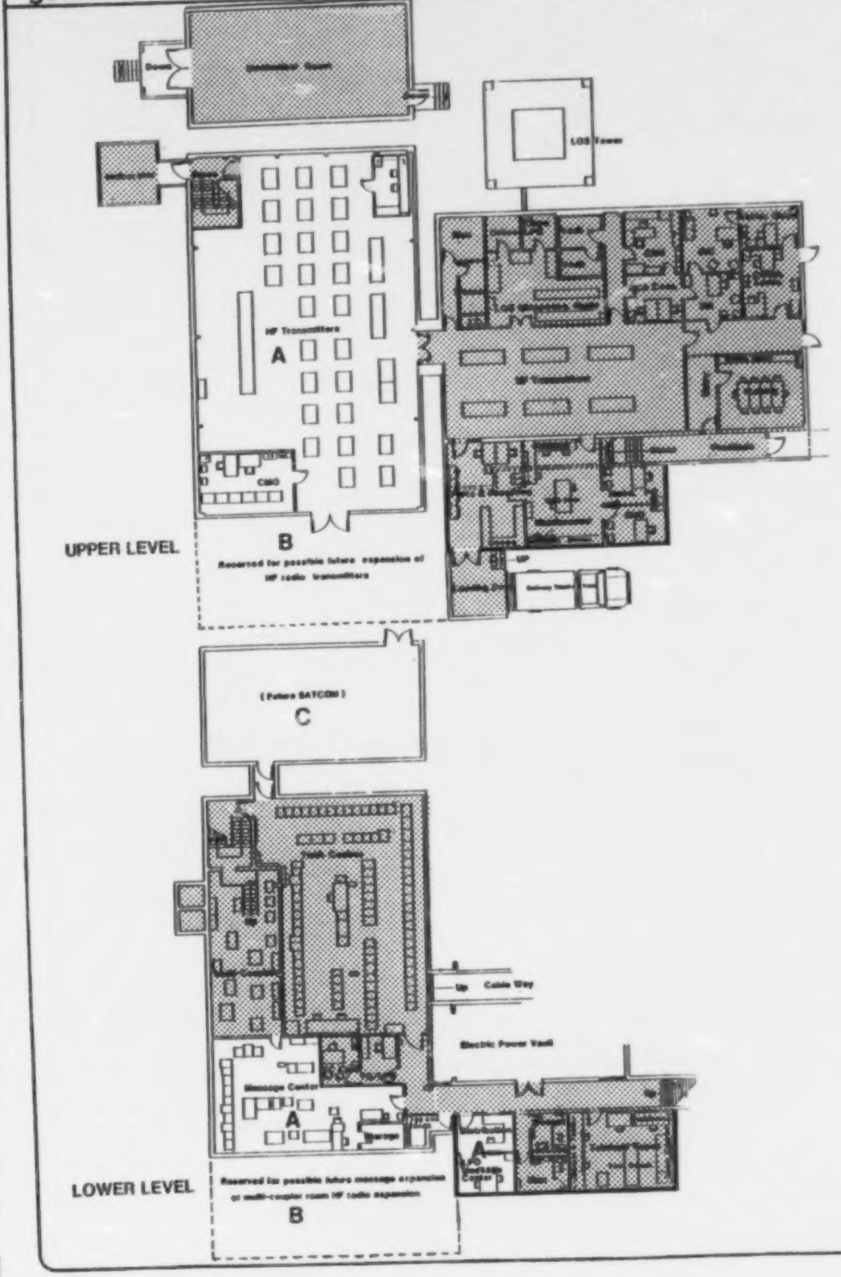


LOWER LEVEL

A Administration modules are easily accessible to the public to minimize circulation and prevent visitor interference with facility operations. The administration module provides a buffer and transition space between the exterior and secure interior spaces. Also, public corridors in the administrative area will contain the military unit logos and other display panels related to the "esprit de corps" and the communication station's unit integrity.

B The administration spaces' integrated relationship will improve efficiency by minimizing public and administrative circulation through group adjacency to a shared conference (training) area, clerk, workstations, and waiting areas.

guidance 4 Facility Expansion

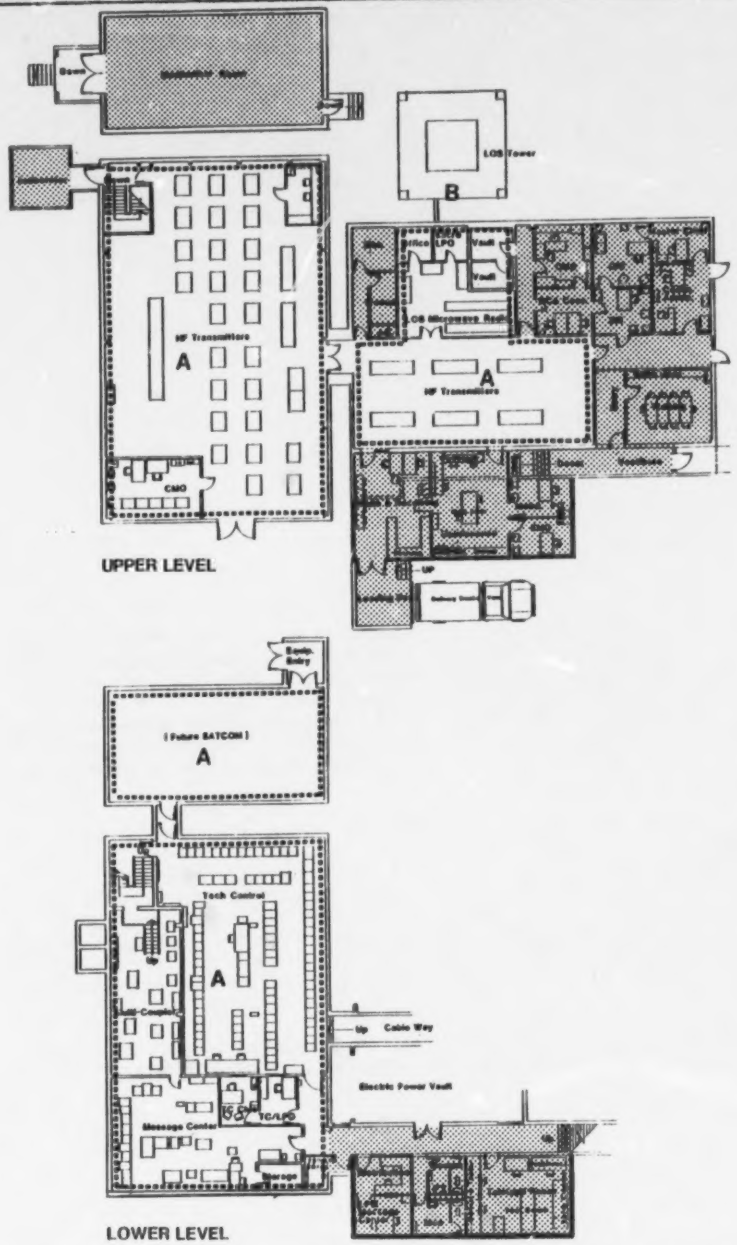

LOS Tower
HF Transmitters
A
CMO
UPPER LEVEL
B
Reserved for possible future expansion of HF radio transmitters
UP
(Future SATCOM)
C
Up
Cable Way
Electric Power Vault
Message Center
A
Storage
A
LOWER LEVEL
Reserved for possible future message expansion or multi-coupler room HF radio expansion
B

A The equipment layout is planned in a way that allows space for installing equipment that can handle the maximum projected traffic load. The initial equipment layout is such that ultimate expansion of the station facility is possible without extensively rearranging already installed equipment. Space allowance for future equipment needs can be determined as an exact amount if the specific equipment for demands are known, or as an estimate based on the requirements of similar stations.

B Operations spaces are functionally isolated from support and power modules. Due to the increasingly rapid changes in the communications technology, future demands on the operations modules' spatial layout can be expected. These spaces must be expandable to accommodate new equipment and functions. Support and power spaces probably will not need this same expansion capability and, therefore, may be located in their former areas. Facility design should allow operations modules to expand without greatly affecting the remaining functions.

C The facility can respond to major changes in mission or functional requirements such as the addition of a satellite earth terminal.

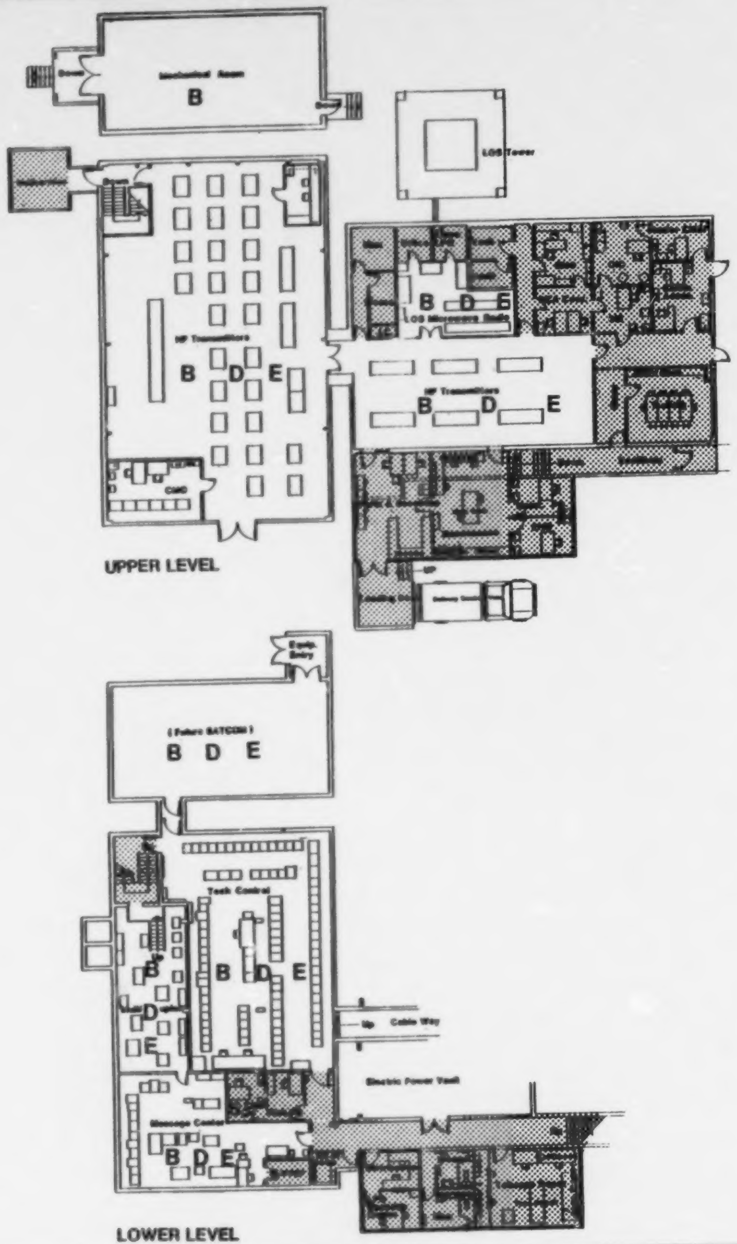
guidance 5 Facility Security / Survivability


Down
LOS Tower
B
Office
LPO
Vault
Vault
LOS Microwave Radio
HF Transmitters
A
HF Transmitters
A
CMO
UP
UPPER LEVEL
Equip. Entry
(Future SATCOM)
A
Tech Control
A
Up
Cable Way
Electric Power Vault
Message Center
TC/LPO
Storage
LOWER LEVEL

A Conventional Class A vault construction is required for all spaces containing the communication system equipment, such as that supporting the HF transmission, message center, and technical control areas. Therefore, efficient construction methods and future building flexibility requirements are achieved by locating these spaces close together. The spaces require vault-type construction to meet four requirements: (1) HEMP protection, (2) TEMPEST shielding, (3) building intrusion resistance, and (4) fire protection. (See SB7, Security Systems--Guidance for building security construction of Zone 4, Section 5b.)

B HF and LOS MW systems require that waveguides be used in transporting the communications signal to and from antennas to the transmission/receiving equipment. It is therefore necessary that the transmission/receiving module be located close to the antennas. In addition, waveguides must be protected physically to ensure the facility's ability to perform its mission.

guidance 6 Fire Protection


Mechanical Room
B
LOS Tower
B D E
LOS Microwave Radio
HF Transmitters
B D E
HF Transmitters
B D E
UPPER LEVEL
Equip. Entry
(Future SATCOM)
B D E
Tech Control
B D E
B
D
E
Cable Way
Electric Power Vault
Message Center
B D E
LOWER LEVEL

Occupancy classifications: Business (NFPA); B-2 (UBC)

Hazard of contents classification: Ordinary hazard

Sprinkler protection classification: Ordinary hazard--group 2

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*See Vol 2, SB7, Security, for vault construction requirements that may be more stringent than those imposed by fire protection requirements.

Construction classifications/materials for fire protection (See Vol 2, SB3, Fire Protection/Life Safety)

Type II--Fire resistive (UBC) for security/armory spaces

CONSTRUCTION ELEMENT

Exterior walls....................	4-hr rated construction
Interior bearing walls............	2-hr rated construction
Structural frame..................	2-hr rated construction
Permanent partitions..............	1-hr rated construction
Shaft enclosures..................	2-hr rated construction
Floors............................	2-hr rated construction
Roofs.............................	2-hr rated construction

B Type II--one-hour (UBC) for battery, cryptography (Red and Black),* custodial, generator, operations,* mechanical, and technical control spaces

All construction elements....... 1-hr rated construction

Type II-N (UBC) for the other building spaces

All construction elements....... Noncombustible construction

Building separation

Site-specific information is required. Comply with Vol 2, SB3, Fire Protection/Life Safety.

guidance 6

Interior finishes

See Guidance/Life Safety.

Fire protection systems

Automatic fire suppression:

A water sprinkler system shall be provided throughout the facility.

Halon 1301 or carbon dioxide system shall be provided under raised floor areas containing nonmetallic sheathed, exposed cables when the space under the raised floor is used as an air plenum.

Automatic notification/alarm:

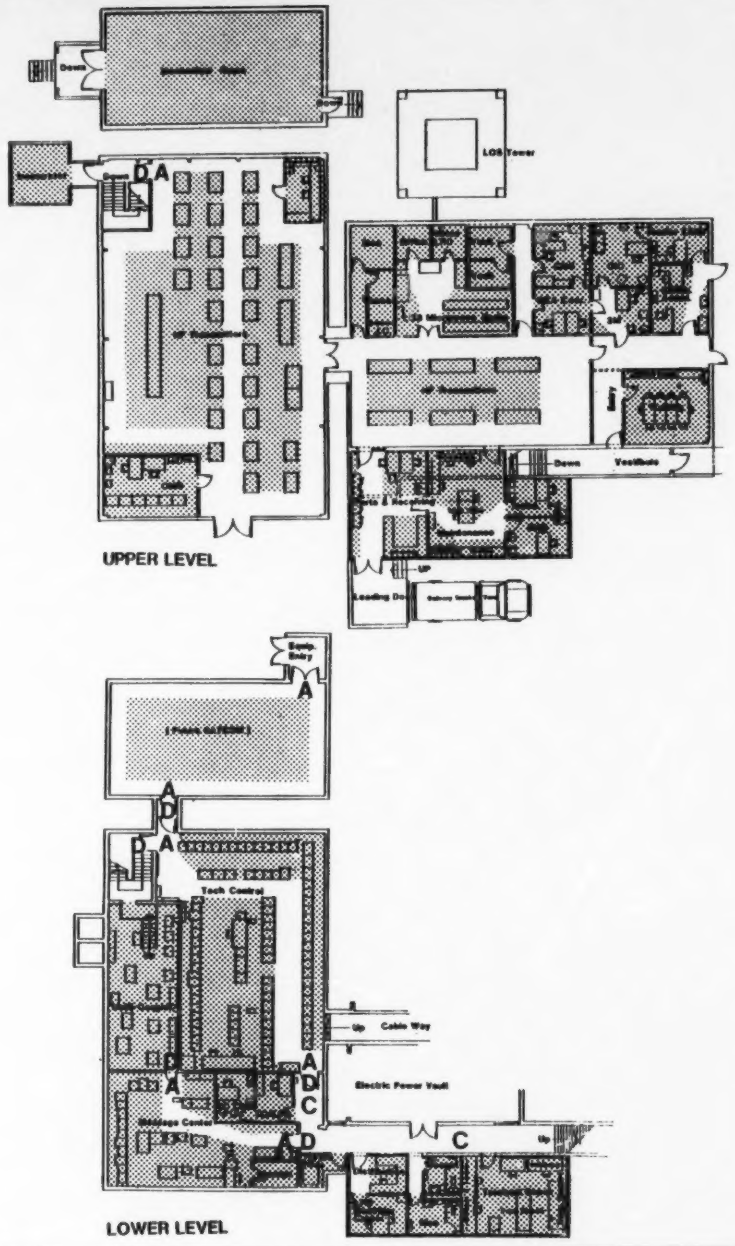
General alarm activated by the automatic sprinkler system.

D Local alarm to sound in these spaces only, activated by smoke detectors.

Automatic fire detection

E Smoke detectors to activate local alarms in these spaces only. In rooms containing raised floor areas, smoke detectors shall be located under the raised floor.

guidance



Exit capacities

Corridors: 100 persons per unit of exit width for traveling either direction. The minimum width of any exit access corridor or passageway shall be 44 inches in the clear.
Doors: 100 persons per unit of exit width (a 3-foot door provides 1-1/2 units of exit width, providing exit capacity for 150 persons).

Number of exits

No less than two exits shall be accessible from every part of every floor. A single exit is permitted when the room or area has (1) a total occupant load of less than 100 persons, (2) direct exit to an open area outside the building at the ground level, and (3) a total travel distance on the same level of no more than 100 feet. (If stairs are involved, they shall be no more than 15 feet high and shall be provided with complete enclosures to separate them from all other building parts.

Exit travel distances

Required exits shall be located to allow access without passage through areas subject to locking. No dead-end corridor shall exceed 50 feet. The travel distance to exits shall be no more than 300 feet when the building is protected throughout by an approved automatic sprinkler system.

Arrangement of means of egress

A Exit access and travel routes to exits are shown in the plan. Exit doors in vaulted areas containing communication system equipment are secured and permit exits only. Exit access routes through vaulted areas from spaces outside these areas are not permitted for security reasons.

Two means of egress shall be provided from higher hazard areas, including mechanical and generator spaces. Exit access from any other space may not pass through mechanical or generator spaces (see exit marking). For security reasons, when mechanical or generator spaces have exit access routes through interior spaces, exit access doors from these spaces, when opened, shall sound an alarm and transmit a signal to the annunciator panel in the security space. Access for normal maintenance in mechanical and generator spaces shall be through the exterior doors.

Interior finishes

C Interior finishes in exit access corridors shall be Class A only.

Interior finishes in the remainder of the building shall be Class A or B only.

guidance 7

Illumination of means of egress

Exits and exit access, including stairs, aisles, corridors, and passageways leading to an exit, shall be illuminated continuously to values no less than 1 footcandle (measured at the floor) while the conditions of occupancy require that a means of egress be available.

Emergency lighting

Emergency lighting shall be provided in windowless buildings for designated aisles, corridors, and passageways leading to an exit. Emergency lighting shall maintain 1 footcandle of illumination throughout the means of egress for 1.5 hours in the event that normal lighting fails.

Marking of means of egress

Exits shall be marked by an approved sign readily visible from any direction of exit access. Sign placement shall be such that no point in the exit access is more than 100 feet from the nearest visible sign.

D Doors located or arranged so they are likely to be mistaken for exits shall be identified by a sign reading "NOT AN EXIT".

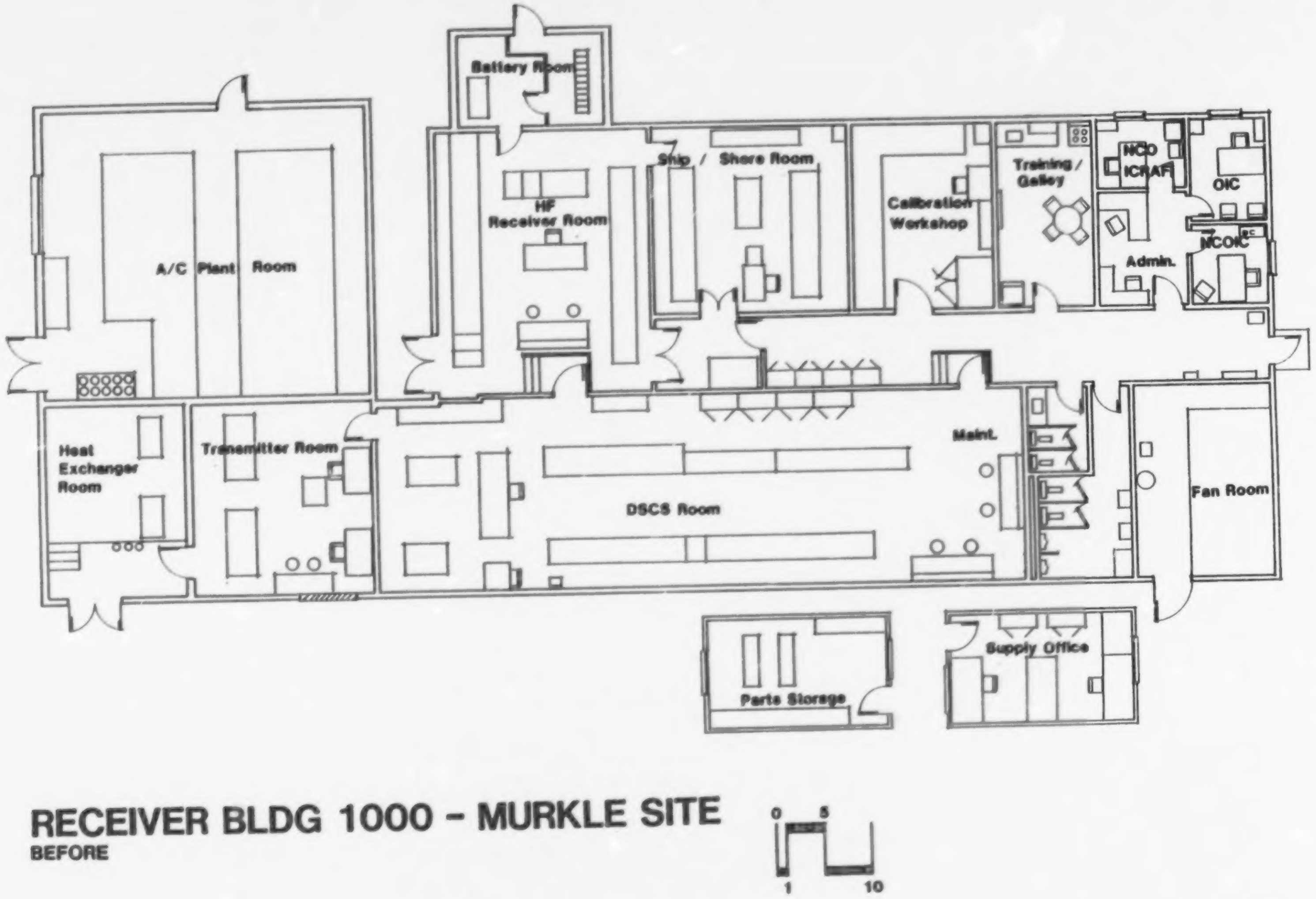
guidance

WEST MURKLE, SCOTLAND

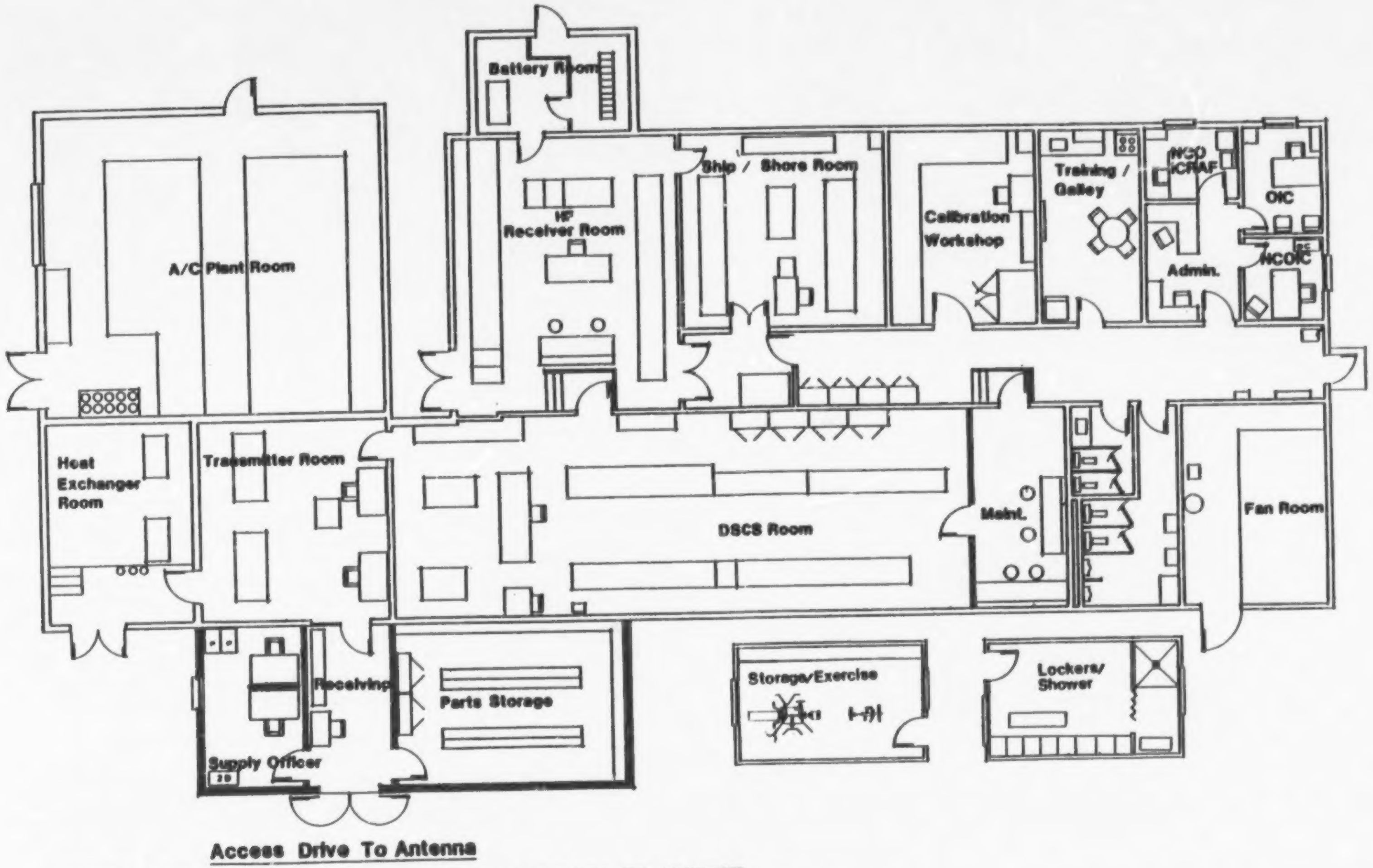
DCS Building Expansion and Retrofit

GIVEN: This remote site has a high frequency (HF) radio receiver and a satellite earth terminal. The maintenance and parts storage areas are in shelters outside the main communication building. There is no indoor exercise equipment (or recreation) area for personnel assigned to this site.

OBJECTIVE: One objective is to have parts and supply spaces well integrated into the main building so that the parts receiving and storage are at the same floor level as the existing operations spaces. Another objective is to establish a distinct maintenance area in part of the satellite terminal operations room to provide an acceptable space for maintenance personnel to make repairs. Also, an exercise room and locker/shower facility are recommended in the areas now used for parts storage.


Battery Room
A/C Plant Room
HF Receiver Room
Ship / Shore Room
Calibration Workshop
Training / Galley
NCO ICRAF
OIC
Admin.
NCOIC
Heat Exchanger Room
Transmitter Room
DSCS Room
Maint.
Fan Room
Parts Storage
Supply Office
0
5
1
10

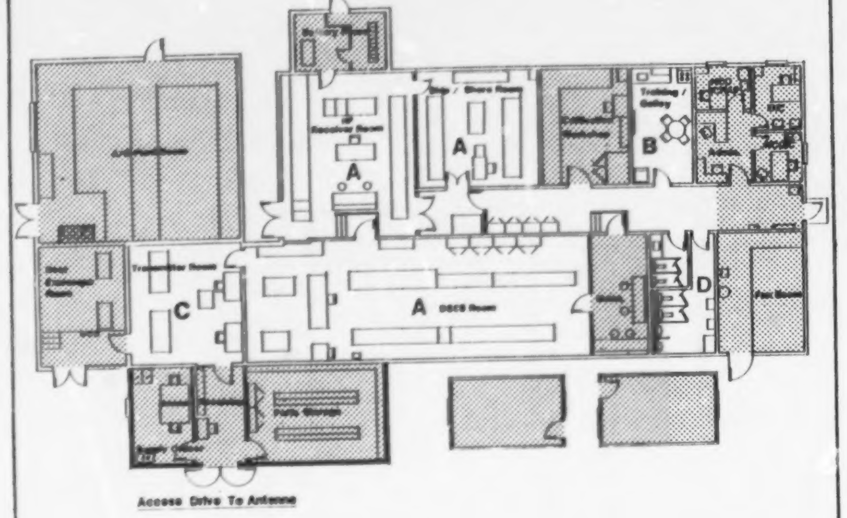
RECEIVER BLDG 1000 - MURKLE SITE
BEFORE


Battery Room
A/C Plant Room
HF Receiver Room
Ship / Shore Room
Calibration Workshop
Training / Galley
NCO CRAF
OIC
Admin.
NCOIC
Heat Exchanger Room
Transmitter Room
DSCS Room
Maint.
Fan Room
Receiving
Supply Officer
Parts Storage
Storage/Exercise
Lockers/ Shower
Access Drive To Antenna
0
5
1
10

RECEIVER BLDG 1000-MURKLE SITE

AFTER

guidance 1 Efficiency of Operational Functions



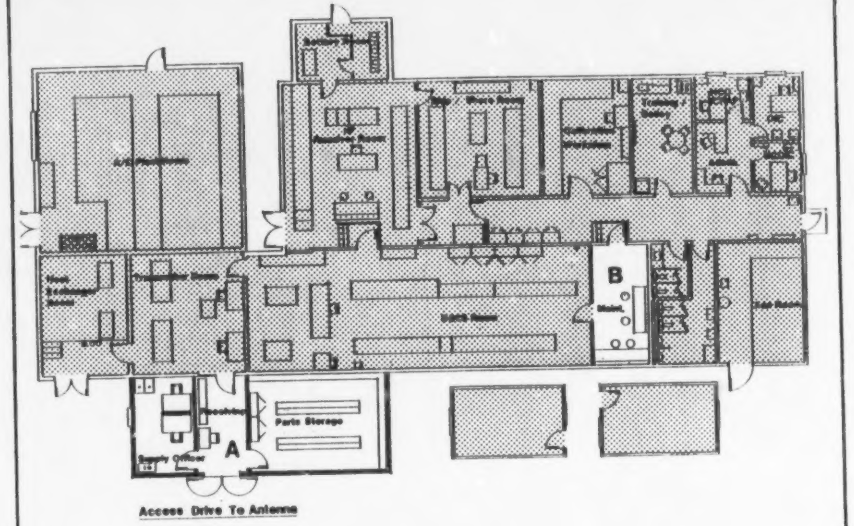
A Equipment is aligned in parallel rows in the operations modules for ease in visual surveillance and for direct access to all critical equipment. Multiple consoles should be adjacent to each other so that limited personnel can monitor them efficiently from one central location. Tables for audiovisual training aids should be available in the operations modules so that personnel can train on the job during regular watch periods.

B To improve the effectiveness of personnel training on the job, small groups of four or five can be instructed in the training room. For this type of training, personnel receive both text instruction and hands-on work with the communications equipment, thus requiring a close relationship between the operations module and the training room.

C Additional building modules that have a close functional relationship to operations activities are located adjacent to the operations module.

D Personnel in the operations modules have easy access to toilet facilities.

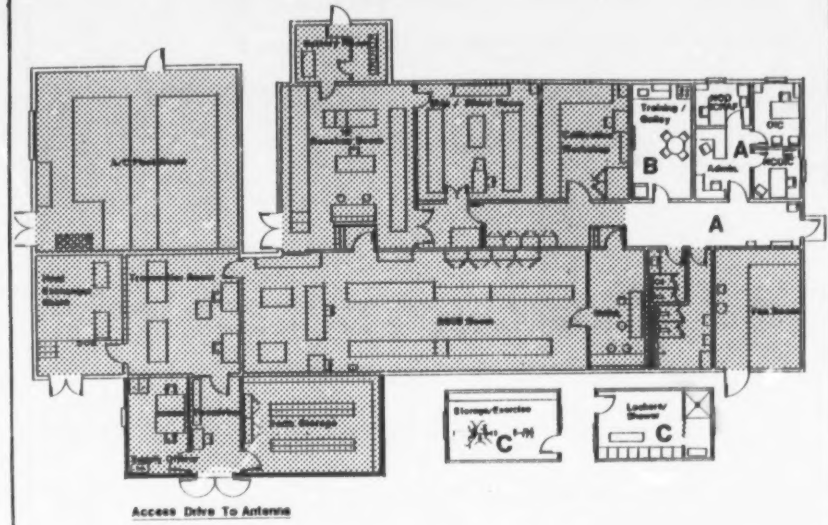
guidance 2 Integintegration of Parts / Maint Modules with Ops



A The new parts receiving and storage rooms are located to be well integrated and close to the operations space for optimal efficiency and minimal circulation. The secure door between the operations and the parts spaces is used only as a fire exit and to bring communication equipment in and out via the loading dock and the receiving room. This door has opening hardware only on the secure side. The receiving room is located within an organizational context such that deliveries can be made efficiently and securely to the total building at the loading dock. Large communication equipment also can be moved in and out more easily using the loading dock.

B The new maintenance room is well integrated and close to the operations spaces for optimal efficiency and minimal circulation. The secure door between the DSCS operations room and the maintenance space is used only as a fire exit and to bring communication equipment in and out for repair or testing. This door has opening hardware only on the secure side.

guidance 3 Efficiency and Accessibility of Admin Spaces

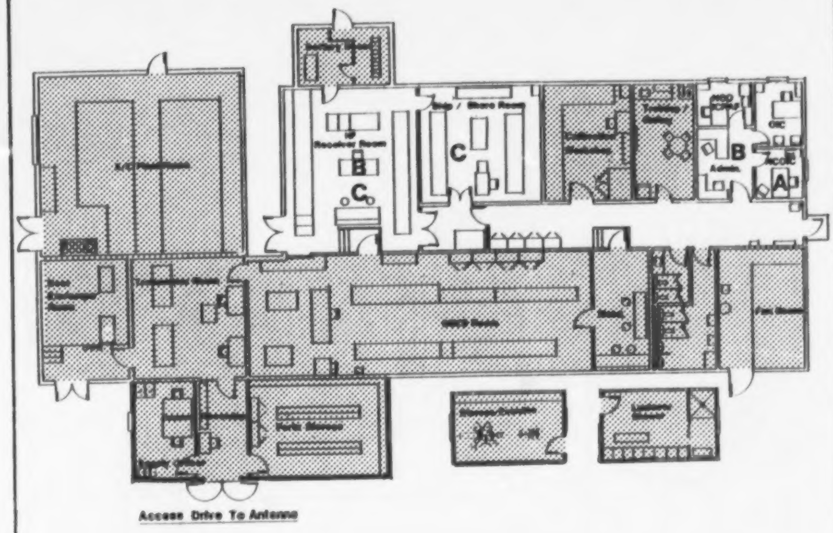


A Administration rooms are easily accessible to the public to minimize circulation and prevent visitor interference with facility operations. The administration module provides a buffer and transition space between the exterior and secure interior spaces. Also, the public corridor in the administrative area contains military unit logos and other display panels related to the "esprit de corps" and the communication station's unit integrity.

B The intense activities in the communication facility tend to generate personnel mental fatigue. It is therefore necessary to create a change of environment for on-duty personnel as a break from the hard-surface equipment room and work areas. The personnel support galley is close to the operations rooms, but isolated acoustically and visually.

C The provision of physical exercise equipment is considered necessary for this station since it is remote from the main military base. The showers and lockers are adjacent to the exercise room for easy accessibility and optimal use.

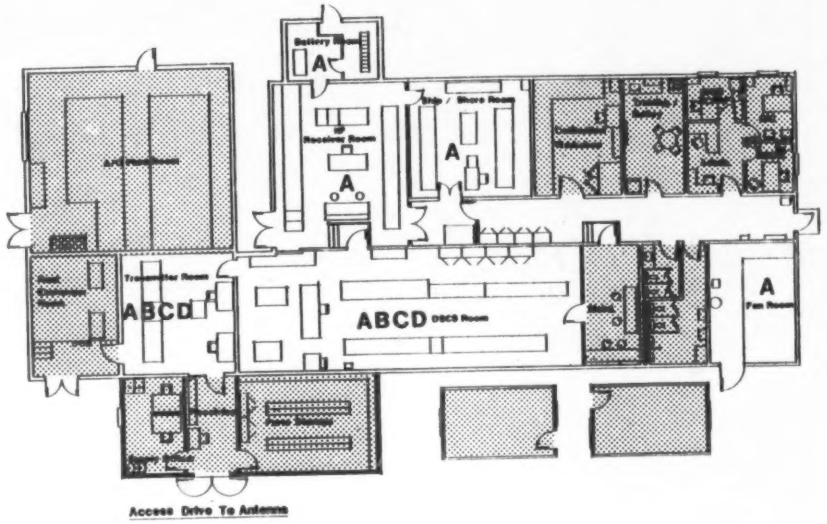
guidance 4 Security Operation



A The security noncommissioned officer in charge (NCOIC) is located to provide an overview for entry verification of visiting personnel. In addition, this person must be easily accessible to building occupants to facilitate security checks.

B Personnel in the administration room can monitor all intrusion detection systems and initiate appropriate reactions to hostile threats. The security detection devices also can be monitored at the shift chief workstation in the receiver room for night and weekend operations.

C "Message" security is achieved by minimizing circulation into operations rooms that contain cryptography equipment, confining the equipment to controlled areas, and using disposal techniques performed or controlled by appropriate personnel.



Occupancy classifications: Business (NFPA); B-2 (UBC)

Hazard of contents classification: Ordinary hazard

Sprinkler protection classification: Ordinary hazard--group 2

Construction classifications/materials for fire protection (See Vol 2, SB3, Fire Protection/Life Safety)

Type II--Fire resistive (UBC) for security/armory spaces

CONSTRUCTION ELEMENT

Exterior walls	4-hr rated construction
Interior bearing walls	2-hr rated construction
Structural frame	2-hr rated construction
Permanent partitions	1-hr rated construction
Shaft enclosures	2-hr rated construction
Floors	2-hr rated construction
Roofs	2-hr rated construction

A Type II--one-hour (UBC) for battery, cryptography (Red and Black),* custodial, generator, operations,* mechanical, and technical control spaces

All construction elements....... 1-hr rated construction

Type II-N (UBC) for the other building spaces

All construction elements....... Noncombustible construction

Building separation

Site-specific information is required. Comply with Vol 2, SB3, Fire Protection/Life Safety.

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*See Vol 2, SB7, Security, for vault construction requirements that may be more stringent than those imposed by fire protection requirements.

guidance 5

Interior finishes

See Guidance/Life Safety.

Fire protection systems

Automatic fire suppression:

A water sprinkler system shall be provided throughout the facility.

B Halon 1301 or carbon dioxide system shall be provided under raised floor areas containing nonmetallic sheathed, exposed cables when the space under the raised floor is used as an air plenum.

Automatic notification/alarm:

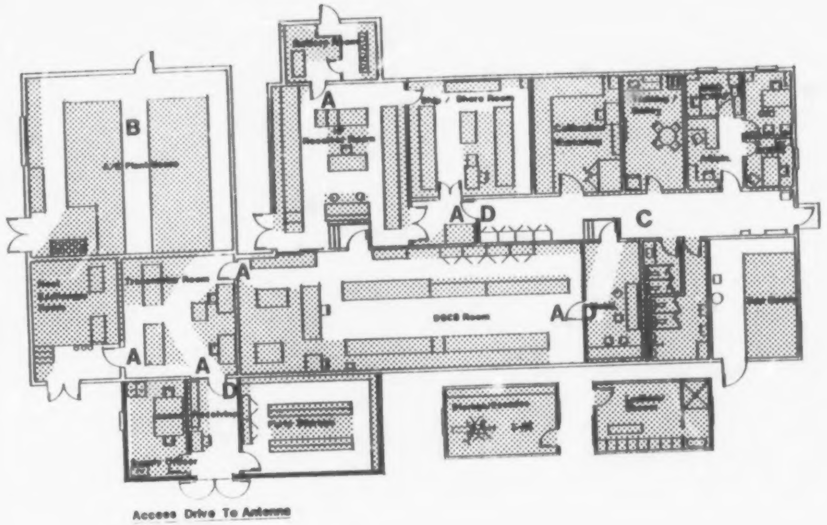
General alarm activated by the automatic sprinkler system.

C Local alarm to sound in these spaces only, activated by smoke detectors.

Automatic fire detection

D Smoke detectors to activate local alarms in these spaces only. In rooms containing raised floor areas, smoke detectors shall be located under the raised floor.

guidance



Exit capacities

Corridors: 100 persons per unit of exit width for traveling either direction. The minimum width of any exit access corridor or passageway shall be 44 inches in the clear.
Doors: 100 persons per unit of exit width (a 3-foot door provides 1-1/2 units of exit width, providing exit capacity for 150 persons).

Number of exits

No less than two exits shall be accessible from every part of every floor. A single exit is permitted when the room or area has (1) a total occupant load of less than 100 persons, (2) direct exit to an open area outside the building at the ground level, and (3) a total travel distance on the same level of no more than 100 feet. (If stairs are involved, they shall be no more than 15 feet high and shall be provided with complete enclosures to separate them from all other building parts.

Exit travel distances

Required exits shall be located to allow access without passage through areas subject to locking. No dead-end corridor shall exceed 50 feet. The travel distance to exits shall be no more than 300 feet when the building is protected throughout by an approved automatic sprinkler system.

Arrangement of means of egress

Exit access and travel routes to exits are shown in the plan.

A Exit doors in vaulted areas containing communication system equipment are secured and permit exits only. Exit access routes through vaulted areas from spaces outside these areas are not permitted for security reasons.

B Two means of egress shall be provided from higher hazard areas, including mechanical and generator spaces. Exit access from any other space may not pass through mechanical or generator spaces (see exit marking). For security reasons, when mechanical or generator spaces have exit access routes through interior spaces, exit access doors from these spaces, when opened, shall sound an alarm and transmit a signal to the annunciator panel in the security space. Access for normal maintenance in mechanical and generator spaces shall be through the exterior doors.

Interior finishes

C Interior finishes in exit access corridors shall be Class A only.

Interior finishes in the remainder of the building shall be Class A or B only.

guidance 8

Illumination of means of egress

Exits and exit access, including stairs, aisles, corridors, and passageways leading to an exit, shall be illuminated continuously to values no less than 1 footcandle (measured at the floor) while the conditions of occupancy require that a means of egress be available.

Emergency lighting

Emergency lighting shall be provided in windowless buildings for designated aisles, corridors, and passageways leading to an exit. Emergency lighting shall maintain 1 footcandle of illumination throughout the means of egress for 1.5 hours in the event that normal lighting fails.

Marking of means of egress

Exits shall be marked by an approved sign readily visible from any direction of exit access. Sign placement shall be such that no point in the exit access is more than 100 feet from the nearest visible sign.

D Doors located or arranged so they are likely to be mistaken for exits shall be identified by a sign reading "NOT AN EXIT".

guidance

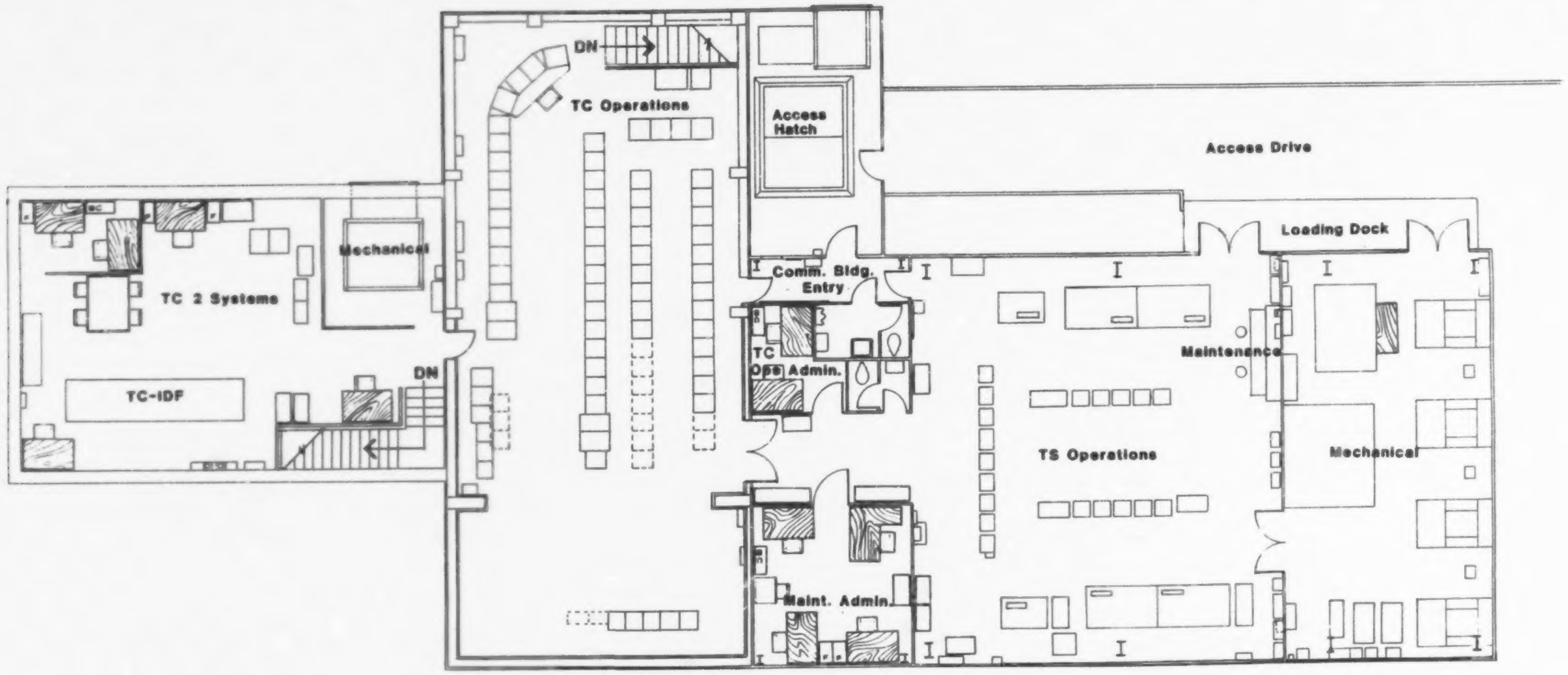
MONTE VERGINE, ITALY

MONTE VERGINE, ITALY

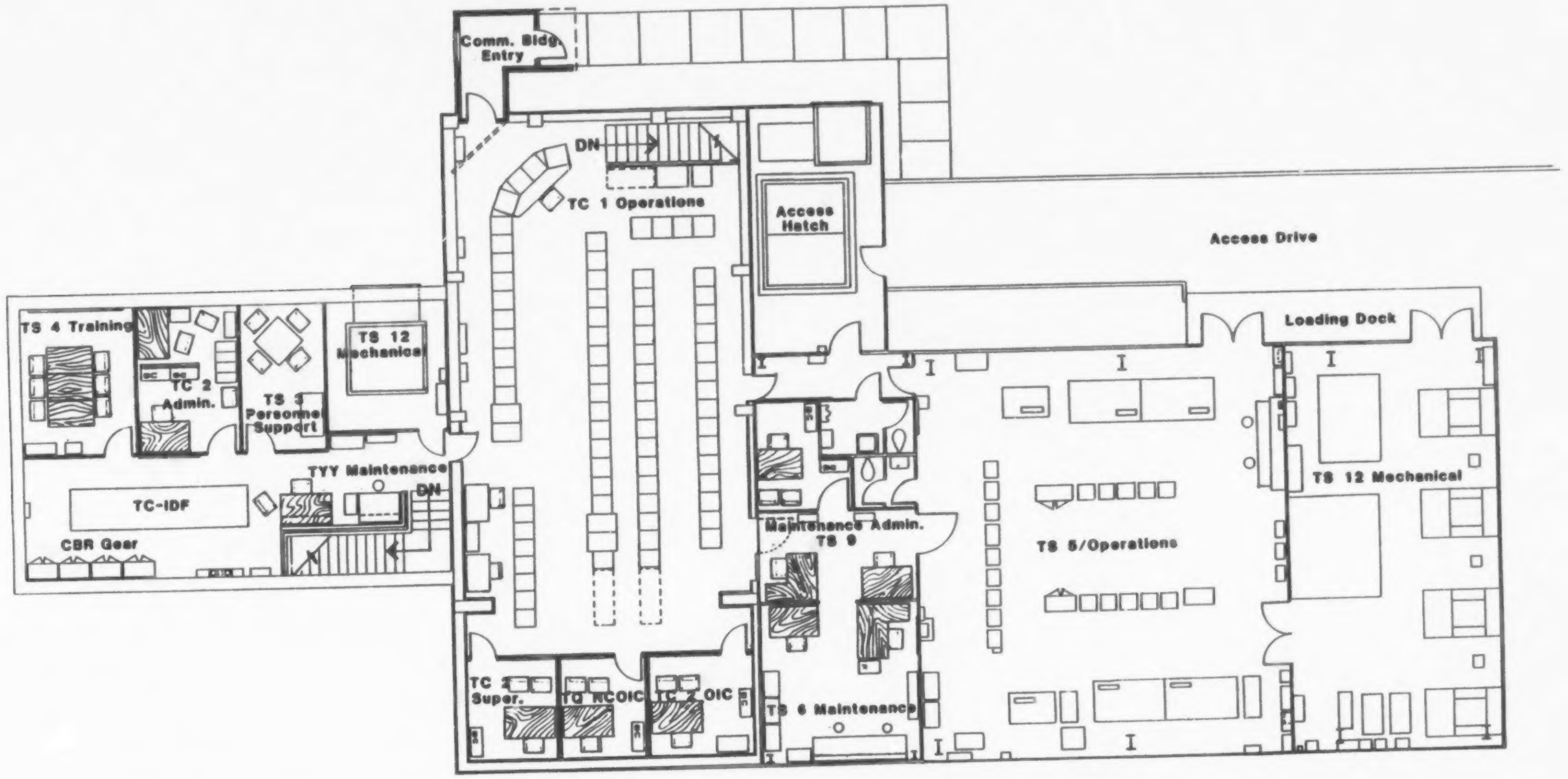
DCS Equipment Building Expansion and Retrofit

GIVEN: This building houses a DCS tropospheric scatter (TS) transmission module, an AUTOVON switch, and a technical control (TC) space. The AUTOVON backup power batteries are located in the AUTOVON operations space rather than in a separate, well ventilated room. Almost all noncommissioned officer (NCO) workstations, training tables, and maintenance workbenches are scattered throughout the TS, TC, and AUTOVON operations spaces.

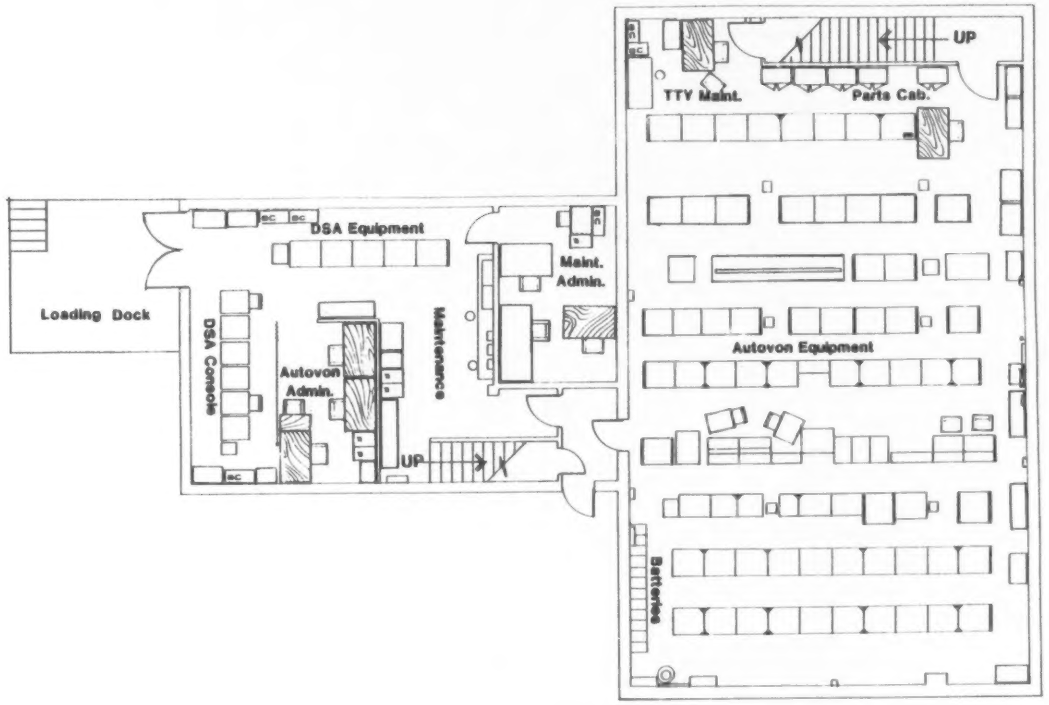
OBJECTIVE: The objective of retrofit expansion is to add new building space and create separate, distinct spaces within the existing two-story building. The new spaces in the existing building are for maintenance and operations NCOICs, personnel support, and training/coordination. Both the personnel support space and the training/coordination room are for use by all (TS, TC, and AUTOVON) personnel. The new construction space is to create a separate, distinct battery room. A major problem with the existing layout is that personnel are required to do maintenance activities under cool temperatures in the operations room. (The room temperature must be kept low to maintain proper conditions for the TS radio transmitter.) Separating the maintenance spaces from operation spaces would optimize environmental conditions for both and thus is a design objective.


DN
TC Operations
Access Hatch
Access Drive
Loading Dock
Mechanical
TC 2 Systems
Comm. Bldg. Entry
TC Ops Admin.
Maintenance
TC-IDF
DN
TS Operations
Mechanical
Maint. Admin.

30 ELECTRONIC EQUIPMENT BUILDING
UPPER LEVEL
BEFORE

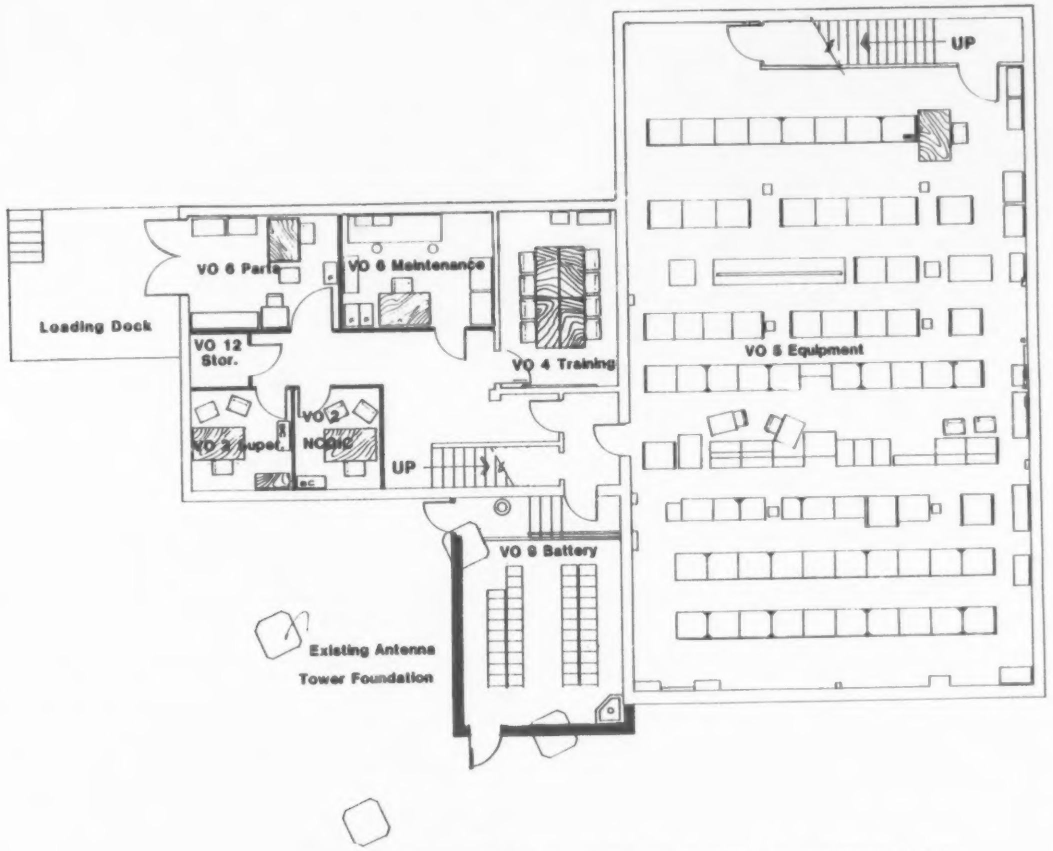

Comm. Bldg. Entry
DN
TC 1 Operations
Access Hatch
Access Drive
Loading Dock
TS 4 Training
TC 2 Admin.
TS 3 Personnel Support
TS 12 Mechanical
TYY Maintenance
DN
TC-IDF
CBR Gear
Maintenance Admin. TS 9
TS 5/Operations
TS 12 Mechanical
TC 2 Super.
TC NCOIC
TC 2 OIC
TS 6 Maintenance
0
5
1
10

30 ELECTRONIC EQUIPMENT BUILDING
UPPER LEVEL
AFTER


UP
TTY Maint.
Parts Cab.
BC
DSA Equipment
Maint.
Admin.
Loading Dock
DSA Console
Autovon
Admin.
Maintenance
Autovon Equipment
UP
Batteries

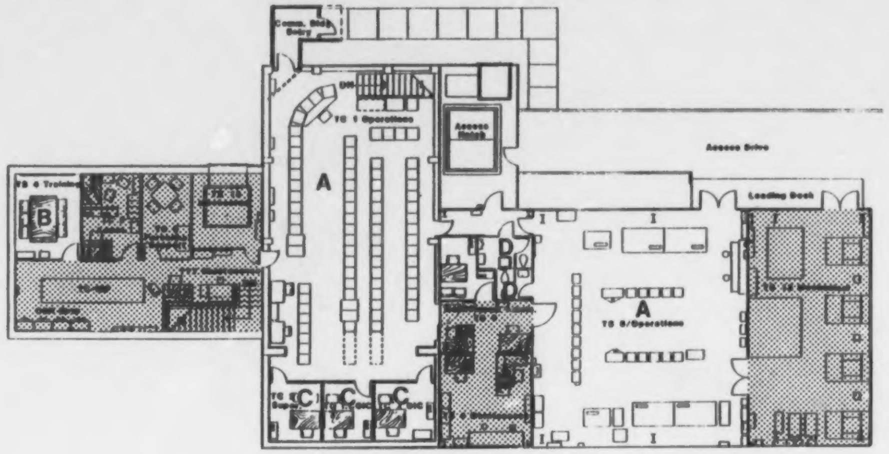
30 ELECTRONIC EQUIPMENT BUILDING
LOWER LEVEL
BEFORE

0 5
1 10

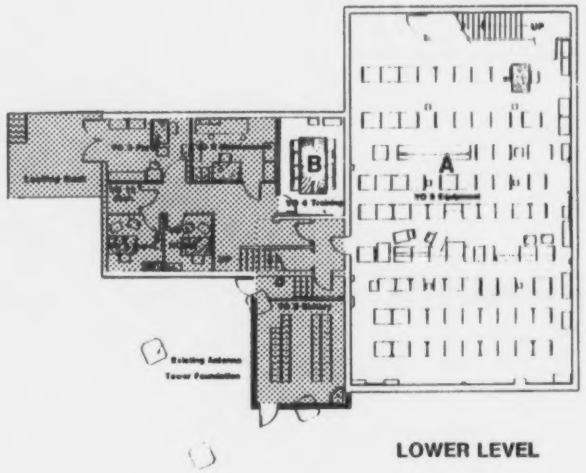

UP
Loading Dock
VO 6 Parts
VO 6 Maintenance
VO 4 Training
VO 12 Stor.
VO 3 Super.
VO 2 NCOIC
UP
VO 5 Equipment
VO 9 Battery
Existing Antenna
Tower Foundation
0
5
1
10

30 ELECTRONIC EQUIPMENT BUILDING
LOWER LEVEL
AFTER

guidance 1 Efficiency of Operational Functions


Comm. Bldg Entry
TC 1 Operations
Access Hatch
Access Drive
Loading Dock
TS 5/Operations
A
A
B
C
C
C
D
D

UPPER LEVEL


UP
Loading Dock
A
B
Existing Antenna Tower Foundation

LOWER LEVEL

A Equipment is aligned in parallel rows in the operations and equipment modules for easy visual surveillance and direct access to all critical equipment. Consoles in the TC operations space are adjacent to the new entry so that limited personnel can monitor them efficiently from one central location. Tables for audiovisual training aids are available in the TC operations module so that personnel can train on the job during regular watch periods.

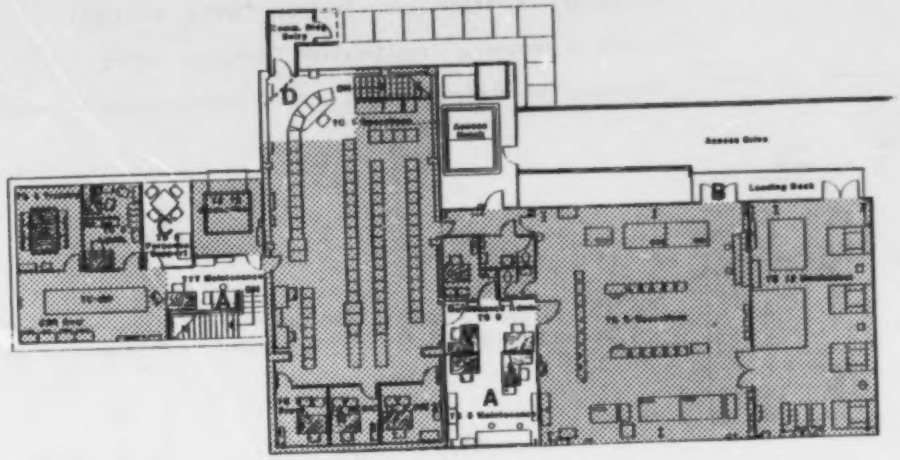
B To improve the effectiveness of personnel training on the job, small groups of four or five can be instructed in the training room. Some TC and AUTOVON training requires both text instruction and hands-on work with the communications equipment; thus the two training rooms are close to the TC operations module and the AUTOVON equipment module.

C Activities that have a close functional relationship to the TC operations activities are located adjacent to the TC module.

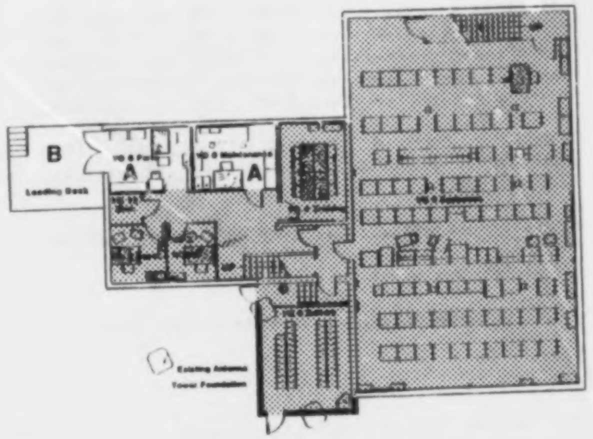
D Personnel in the TC operations and TS operations modules have easy access to toilet facilities.

READEX FICHE

guidance 2 Integration of Parts / Maint Modules with Ops



UPPER LEVEL



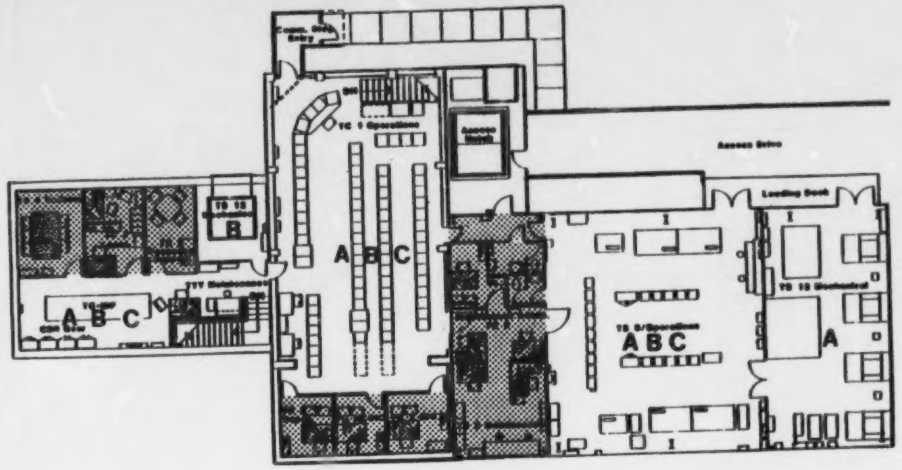
LOWER LEVEL

A Parts and maintenance modules are well integrated and close to the operations spaces for optimal efficiency and minimal circulation. The secure door between TC operations and maintenance administration spaces is used only as a fire exit and to bring communication equipment in and out via the loading dock. This door has opening hardware only on the secure side.

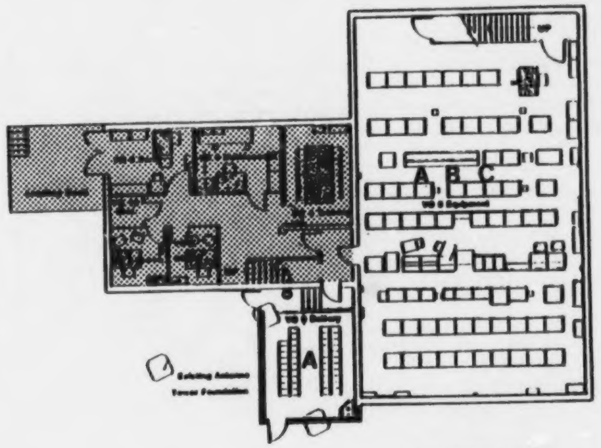
B Maintenance and parts rooms are located such that deliveries can be made directly and securely to the total building at loading docks. Large communication equipment also can be moved in and out more easily using the loading dock.

C The intense activities in the DCS facility tend to generate personnel mental fatigue. It is therefore necessary to create a change of environment for on-duty personnel as a break from the hard-surface equipment room and work areas. The personnel support module is located near the TC operations room, but is isolated acoustically and visually from the equipment spaces.

D In this retrofit, the security checkpoint entry is added near the technical control console to provide an effective overview for verification of entering personnel. In addition, this entry is located to be easily accessible for building occupants coming from other buildings on the Monte Vergine site.



UPPER LEVEL



LOWER LEVEL

Occupancy classifications: Business (NFPA); B-2 (UBC)

Hazard of contents classification: Ordinary hazard

Sprinkler protection classification: Ordinary hazard--group 2

Construction classifications/materials for fire protection (See Vol 2, SB3, Fire Protection/Life Safety)

Type II--Fire resistive (UBC) for security/armory spaces

CONSTRUCTION ELEMENT	
Exterior walls	4-hr rated construction
Interior bearing walls	2-hr rated construction
Structural frame	2-hr rated construction
Permanent partitions	1-hr rated construction
Shaft enclosures	2-hr rated construction
Floors	2-hr rated construction
Roofs	2-hr rated construction

A Type II--one-hour (UBC) for battery, cryptography (Red and Black),* custodial, generator, operations,* mechanical, and technical control spaces

All construction elements....... 1-hr rated construction

Type II-N (UBC) for the other building spaces

All construction elements....... Noncombustible construction

Building separation

Site-specific information is required. Comply with Vol 2, SB3, Fire Protection/Life Safety.

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*See Vol 2, SB7, Security, for vault construction requirements that may be more stringent than those imposed by fire protection requirements.

guidance 3

Interior finishes

See Guidance/Life Safety.

Fire protection systems

Automatic fire suppression:

A water sprinkler system shall be provided throughout the facility.

Halon 1301 or carbon dioxide system shall be provided under raised floor areas containing nonmetallic sheathed, exposed cables when the space under the raised floor is used as an air plenum.

Automatic notification/alarm:

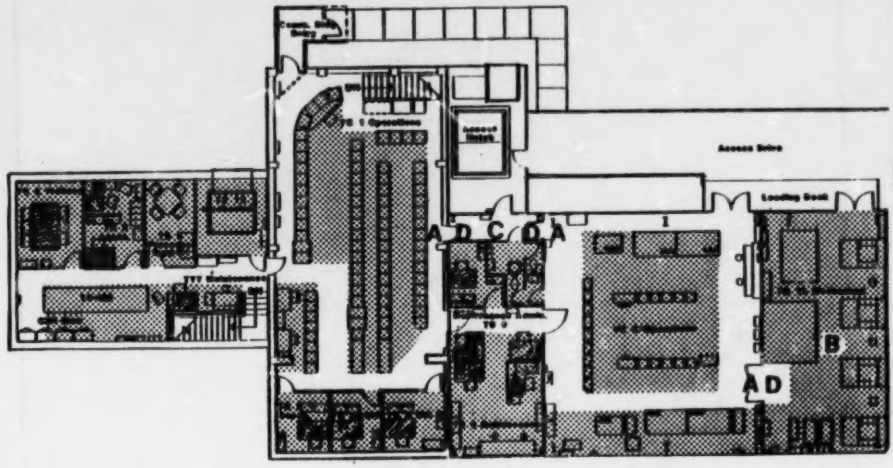
General alarm activated by the automatic sprinkler system.

B Local alarm to sound in these spaces only, activated by smoke detectors.

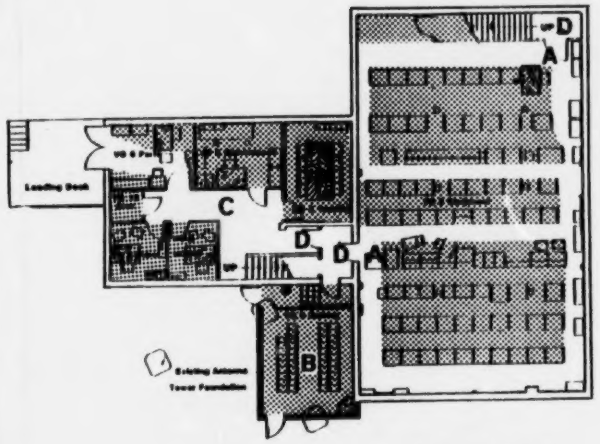
Automatic fire detection

C Smoke detectors to activate local alarms in these spaces only. In rooms containing raised floor areas, smoke detectors shall be located under the raised floor.

guidance



UPPER LEVEL



LOWER LEVEL

Exit capacities

Corridors: 100 persons per unit of exit width for traveling either direction. The minimum width of any exit access corridor or passageway shall be 44 inches in the clear.

Doors: 100 persons per unit of exit width (a 3-foot door provides 1-1/2 units of exit width, providing exit capacity for 150 persons).

Number of exits

No less than two exits shall be accessible from every part of every floor. A single exit is permitted when the room or area has (1) a total occupant load of less than 100 persons, (2) direct exit to an open area outside the building at the ground level, and (3) a total travel distance on the same level of no more than 100 feet. (If stairs are involved, they shall be no more than 15 feet high and shall be provided with complete enclosures to separate them from all other building parts.

Exit travel distances

Required exits shall be located to allow access without passage through areas subject to locking. No dead-end corridor shall exceed 50 feet. The travel distance to exits shall be no more than 300 feet when the building is protected throughout by an approved automatic sprinkler system.

Arrangement of means of egress

Exit access and travel routes to exits are shown in the plan.

A Exit doors in vaulted areas containing communication system equipment are secured and permit exits only. Exit access routes through vaulted areas from spaces outside these areas are not permitted for security reasons.

B Two means of egress shall be provided from higher hazard areas, including mechanical and generator spaces. Exit access from any other space may not pass through mechanical or generator spaces (see exit marking). For security reasons, when mechanical or generator spaces have exit access routes through interior spaces, exit access doors from these spaces, when opened, shall sound an alarm and transmit a signal to the annunciator panel in the security space. Access for normal maintenance in mechanical and generator spaces shall be through the exterior doors.

Interior finishes

C Interior finishes in exit access corridors shall be Class A only.

Interior finishes in the remainder of the building shall be Class A or B only.

guidance 4

Illumination of means of egress

Exits and exit access, including stairs, aisles, corridors, and passageways leading to an exit, shall be illuminated continuously to values no less than 1 footcandle (measured at the floor) while the conditions of occupancy require that a means of egress be available.

Emergency lighting

Emergency lighting shall be provided in windowless buildings for designated aisles, corridors, and passageways leading to an exit. Emergency lighting shall maintain 1 footcandle of illumination throughout the means of egress for 1.5 hours in the event that normal lighting fails.

Marking of means of egress

Exits shall be marked by an approved sign readily visible from any direction of exit access. Sign placement shall be such that no point in the exit access is more than 100 feet from the nearest visible sign.

D Doors located or arranged so they are likely to be mistaken for exits shall be identified by a sign reading "NOT AN EXIT".

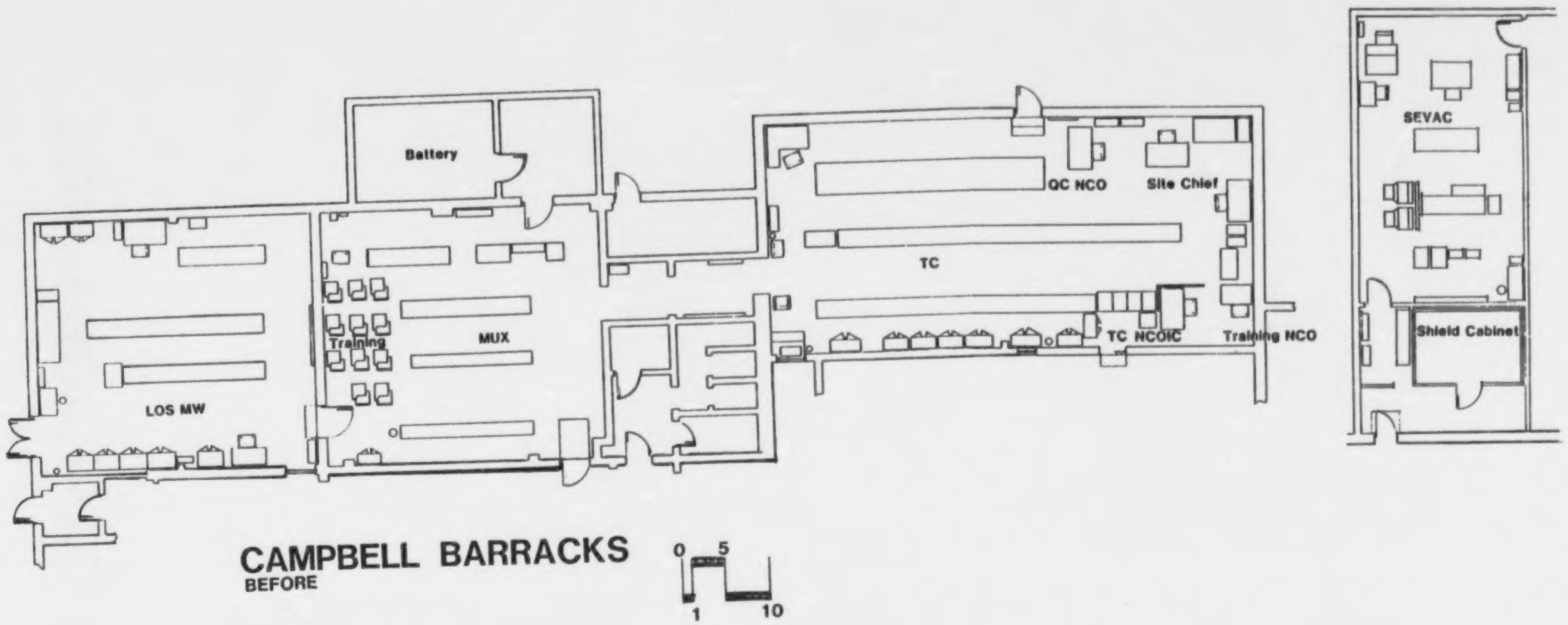
guidance

CAMPBELL BARRACKS, FRG

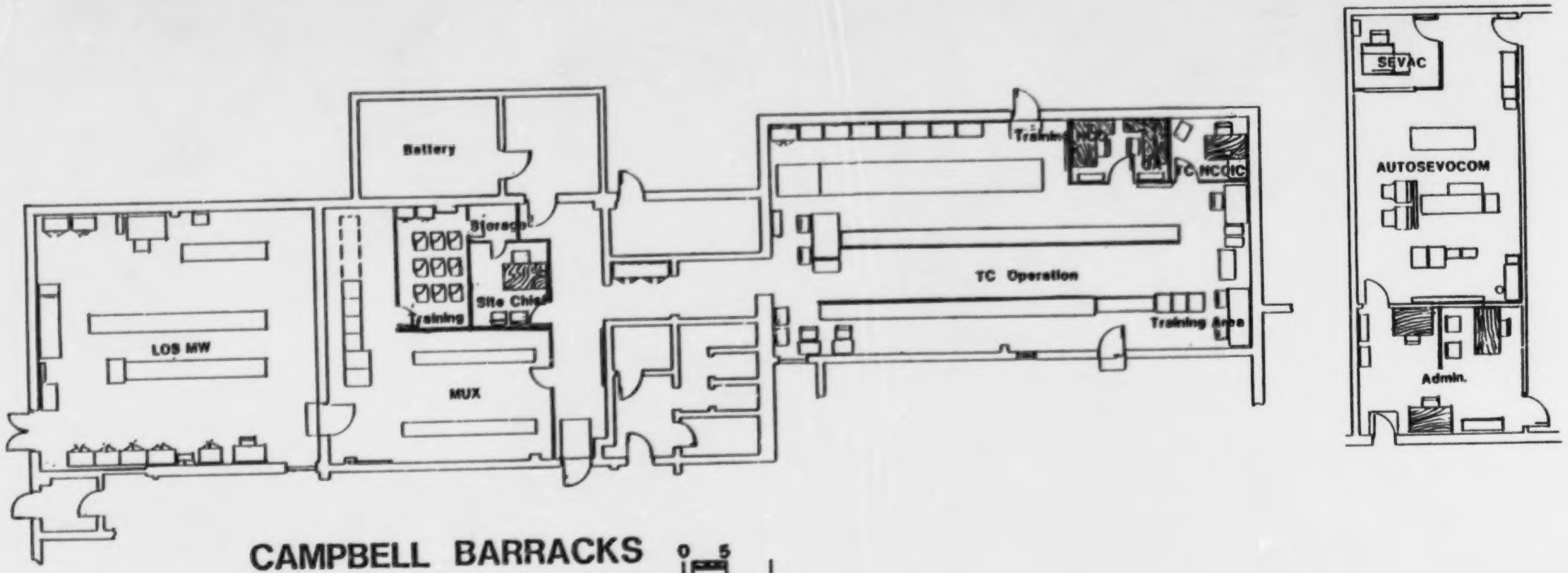
CAMPBELL BARRACKS, FRG

GIVEN: This is a one-story building, part of which is used by a line-of-sight (LOS) microwave (MW) transmission station with accompanying technical control (TC). Another area of the same building, remote from the LOS MW and TC areas, houses an AUTOSEVOCOM. The entire AUTOSEVOCOM is in one large space; however, since the SEVAC console of the AUTOSEVOCOM equipment is quite noisy, it is distracting for administrative personnel and noncommissioned officers in charge (NCOICs) who work in the same place.

OBJECTIVE: The retrofit design objective is to establish distinct spaces for all operations NCOs in the AUTOSEVOCOM, LOS MW, and TC communication spaces. Also, a separate area should be enclosed for station personnel training sessions. Here, audiovisual units and technical manuals could be used for both single and group training sessions to upgrade personnel capabilities.


Battery
LOS MW
Training
MUX
TC
QC NCO
Site Chief
TC NCOIC
Training NCO
SEVAC
Shield Cabinet
0
5
1
10

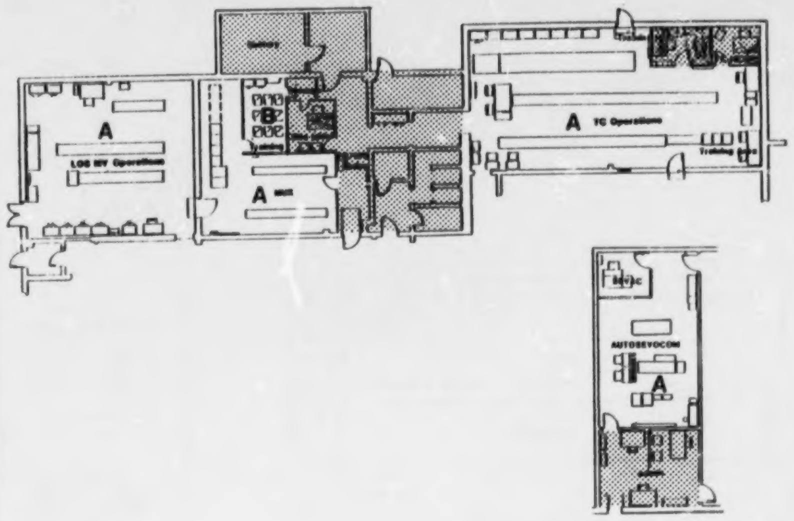
CAMPBELL BARRACKS
BEFORE


Battery
Storage
Training
Site Chief
LOS MW
MUX
Training NCO
TC NCOIC
TC Operation
Training Area
SEVAC
AUTOSEVOCOM
Admin.

CAMPBELL BARRACKS
AFTER

0
5
1
10

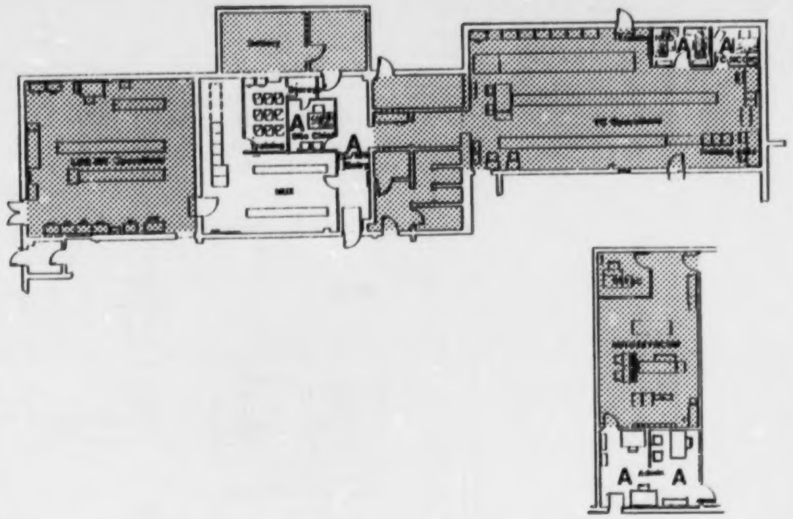
guidance 1 Efficiency of Operational Functions



A Equipment is aligned in parallel rows in the operations modules for easy visual surveillance and direct access to all critical equipment. The shift supervisor and shift personnel table/desks in the TC area are adjacent to each other so that a limited number of shift personnel can run the TC efficiently and also conduct training at one location. Audiovisual aids should be available in operations modules so that personnel can train on the job during regular watch periods.

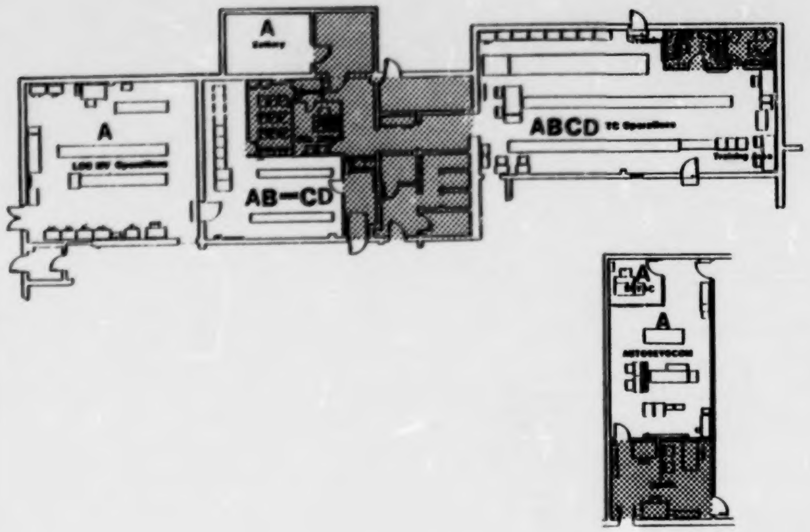
B To improve the effectiveness of personnel training, small groups of four or five can be instructed in the training room. Some instruction combines text lessons and hands-on training work with the communications equipment; thus, the training room is located close to both operations modules.

guidance 2 Efficiency and Accessibility of Admin Spaces



A The site chief and other administrative spaces are located for easy access by the public to minimize circulation and prevent visitor interference with facility operations. The administration area provides a buffer and transition space between the exterior and secure interior spaces. Also, the public entrance in the administrative area contains the military unit logo and other display panels relating to the "esprit de corps" and the communication station's unit integrity.

guidance 3. Fire Protection



Occupancy classifications: Business (NFPA); B-2 (UBC)

Hazard of contents classification: Ordinary hazard

Sprinkler protection classification: Ordinary hazard--group 2

Construction classifications/materials for fire protection (See Vol 2, SB3, Fire Protection/Life Safety)

Type II--Fire resistive (UBC) for security/armory spaces

CONSTRUCTION ELEMENT

Exterior walls	4-hr rated construction
Interior bearing walls	2-hr rated construction
Structural frame	2-hr rated construction
Permanent partitions	1-hr rated construction
Shaft enclosures	2-hr rated construction
Floors	2-hr rated construction
Roofs	2-hr rated construction

A Type II--one-hour (UBC) for battery, cryptography (Red and Black),* custodial, generator, operations,* mechanical, and technical control spaces

All construction elements....... 1-hr rated construction

Type II-N (UBC) for the other building spaces

All construction elements....... Noncombustible construction

Building separation

Site-specific information is required. Comply with Vol 2, SB3, Fire Protection/Life Safety.

Interior finishes

See Guidance/Life Safety.

Fire protection systems

Automatic fire suppression:

A water sprinkler system shall be provided throughout the facility.

B Halon 1301 or carbon dioxide system shall be provided under all raised floor areas containing nonmetallic sheathed, exposed cables when the space under the raised floor is used as an air plenum.

Automatic notification/alarm:

General alarm activated by the automatic sprinkler system.

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*See Vol 2, SB7, Security, for vault construction requirements that may be more stringent than those imposed by fire protection requirements.

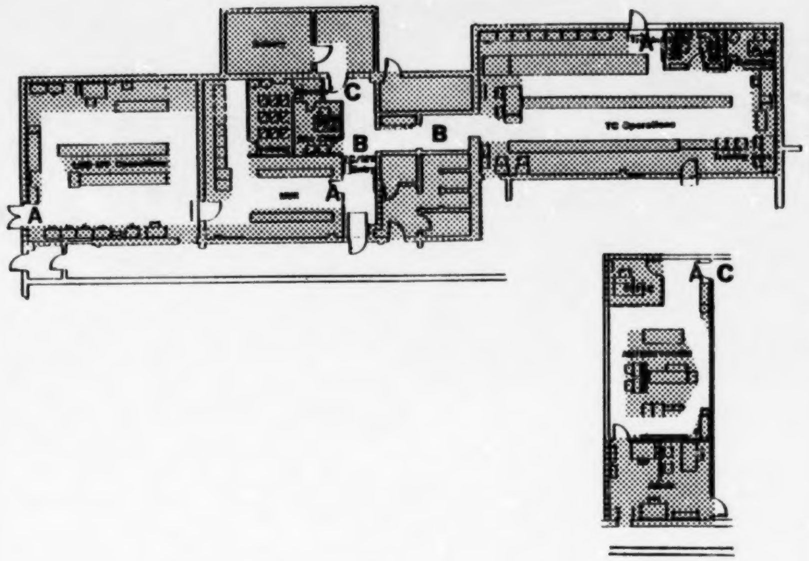
guidance 3

C Local alarm to sound in these spaces only, activated by smoke detectors.

Automatic fire detection

D Smoke detectors to activate local alarms in these spaces only. In rooms containing raised floor areas, smoke detectors shall be located under the raised floor.

guidance



Exit capacities

Corridors: 100 persons per unit of exit width for traveling either direction. The minimum width of any exit access corridor or passageway shall be 44 inches in the clear.
Doors: 100 persons per unit of exit width (a 3-foot door provides 1-1/2 units of exit width, providing exit capacity for 150 persons).

Number of exits

No less than two exits shall be accessible from every part of every floor. A single exit is permitted when the room or area has (1) a total occupant load of less than 100 persons, (2) direct exit to an open area outside the building at the ground level, and (3) a total travel distance on the same level of no more than 100 feet. (If stairs are involved, they shall be no more than 15 feet high and shall be provided with complete enclosures to separate them from all other building parts.

Exit travel distances

Required exits shall be located to allow access without passage through areas subject to locking. No dead-end corridor shall exceed 50 feet. The travel distance to exits shall be no more than 300 feet when the building is protected throughout by an approved automatic sprinkler system.

Arrangement of means of egress

A Exit access and travel routes to exits are shown in the plan. Exit doors in vaulted areas containing communication system equipment are secured and permit exits only. Exit access routes through vaulted areas from spaces outside these areas are not permitted for security reasons.

Two means of egress shall be provided from higher hazard areas, including mechanical and generator spaces. Exit access from any other space may not pass through mechanical or generator spaces (see exit marking). For security reasons, when mechanical or generator spaces have exit access routes through interior spaces, exit access doors from these spaces, when opened, shall sound an alarm and transmit a signal to the annunciator panel in the security space. Access for normal maintenance in mechanical and generator spaces shall be through the exterior doors.

Interior finishes

B Interior finishes in exit access corridors shall be Class A only.

Interior finishes in the remainder of the building shall be Class A or B only.

guidance 4

Illumination of means of egress

Exits and exit access, including stairs, aisles, corridors, and passageways leading to an exit, shall be illuminated continuously to values no less than 1 footcandle (measured at the floor) while the conditions of occupancy require that a means of egress be available.

Emergency lighting

Emergency lighting shall be provided in windowless buildings for designated aisles, corridors, and passageways leading to an exit. Emergency lighting shall maintain 1 footcandle of illumination throughout the means of egress for 1.5 hours in the event that normal lighting fails.

Marking of means of egress

Exits shall be marked by an approved sign readily visible from any direction of exit access. Sign placement shall be such that no point in the exit access is more than 100 feet from the nearest visible sign.

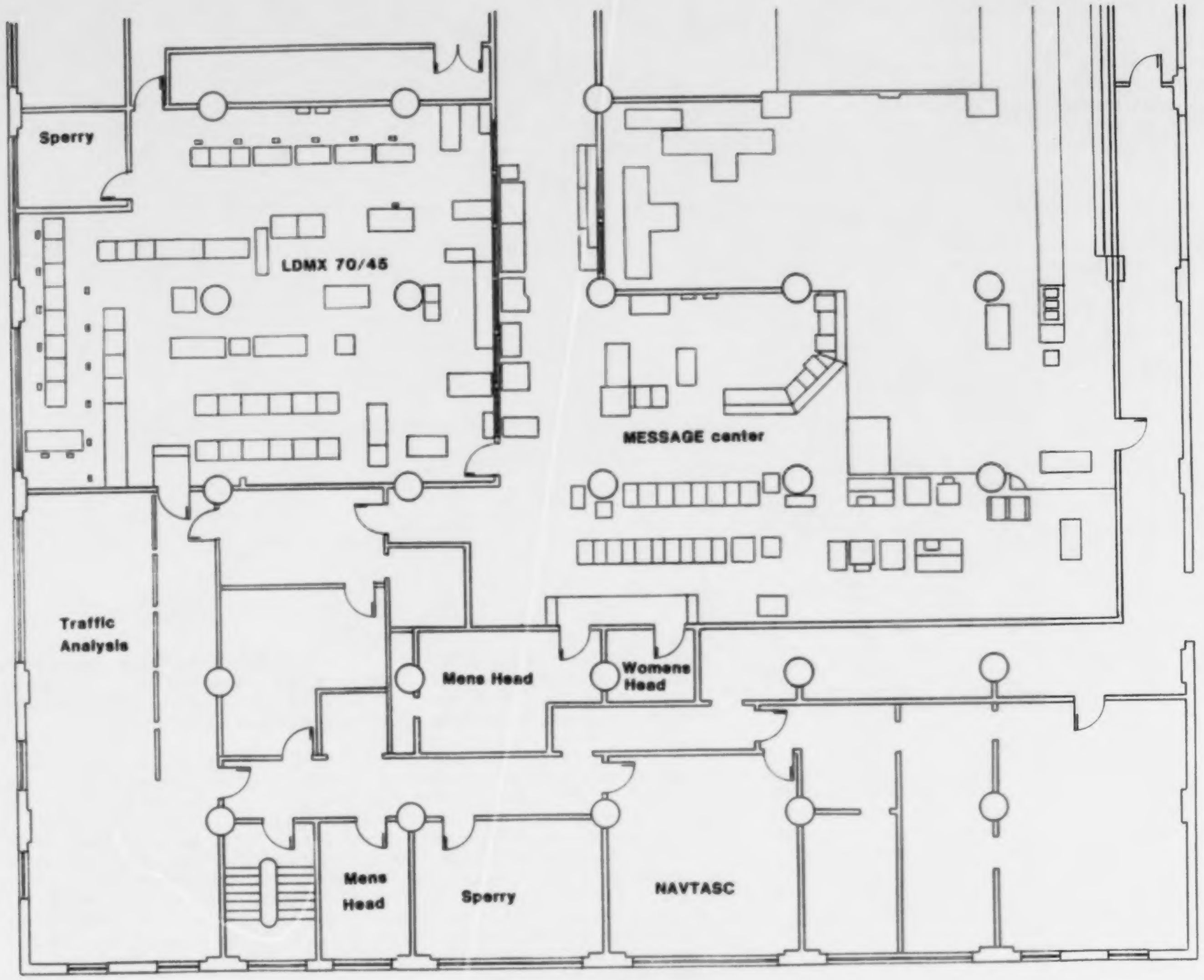
C Doors located or arranged so they are likely to be mistaken for exits shall be identified by a sign reading "NOT AN EXIT".

guidance

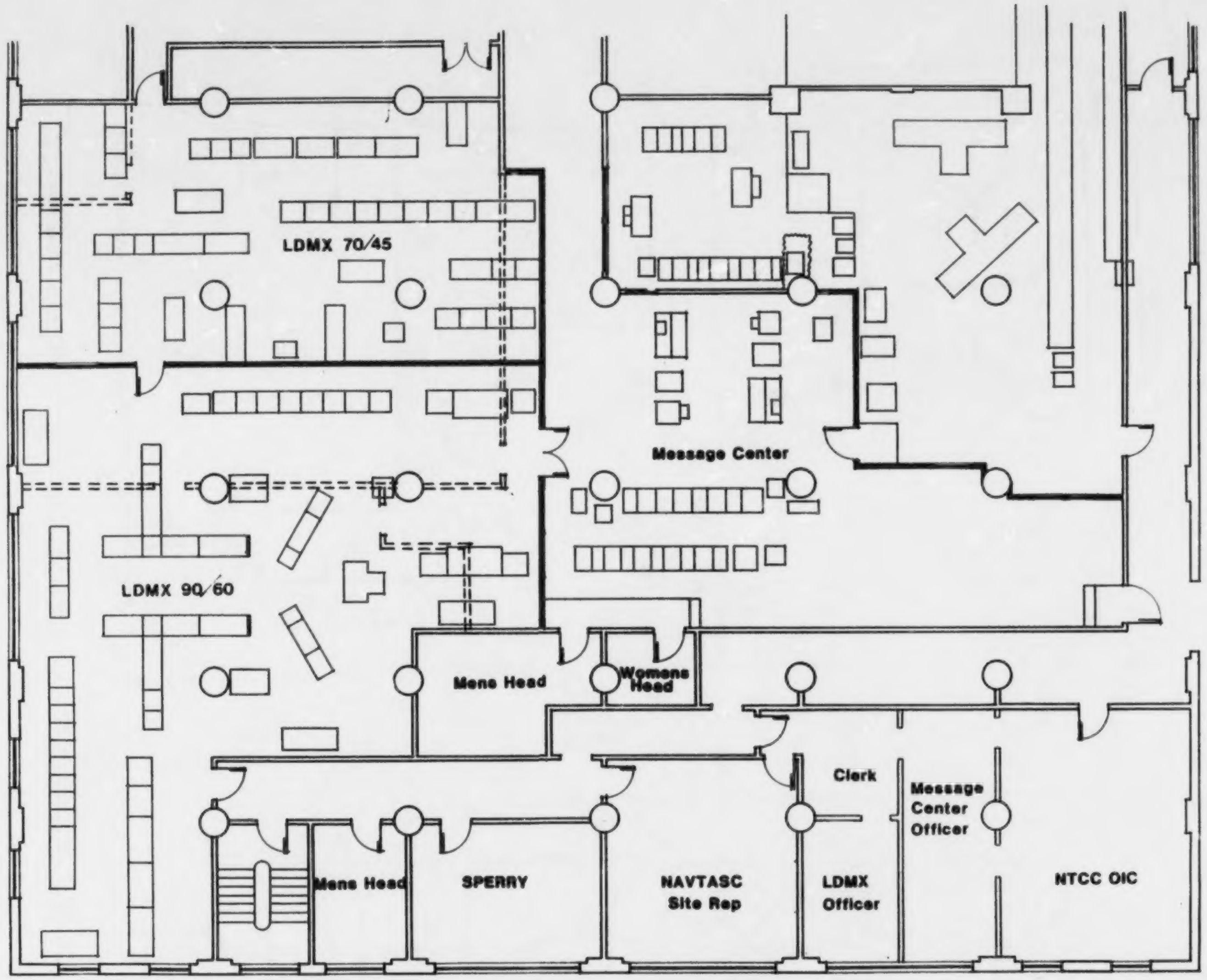
COMSTA SAN DIEGO, CA

GIVEN: This COMSTA is in a multistory building devoted to several military operations, not just DCS communication. The spaces devoted to the COMSTA house an existing 45/70 local digital message exchange (LDMX) as a message center communication facility.

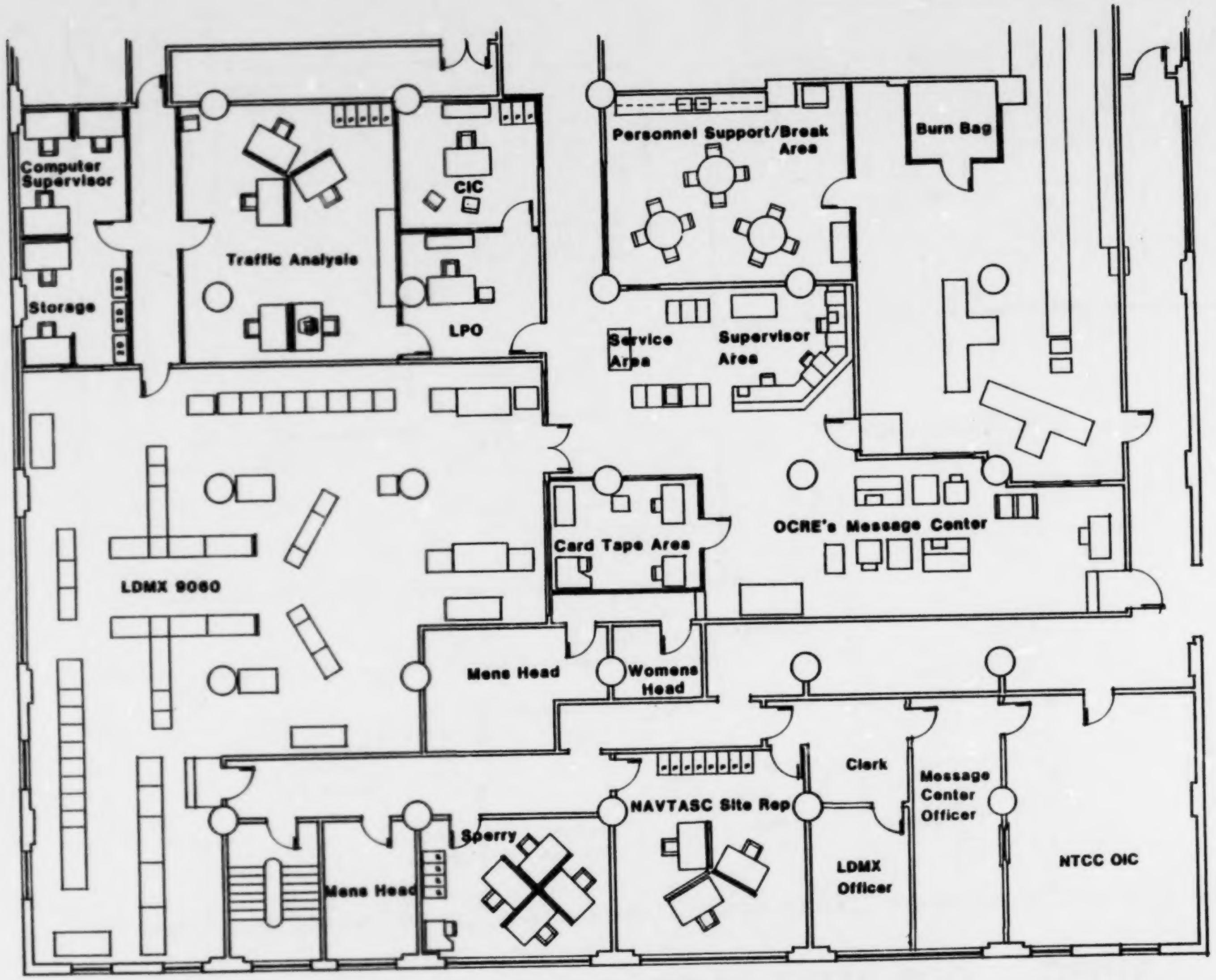
OBJECTIVE: The objective of this retrofit is to set up a two-phase conversion to upgrade the LDMX 45/70 to an LDMX 90/60 as a "hot cutover." This hot cutover will require that both the 45/70 and the 90/60 be operational concurrently. That is, an interim layout is required so the 90/60 can be installed into its assigned space while the 45/70 is still in use. Thus, the total facility would need to be upgraded in two stages. Another goal is to minimize new construction and the demolition of existing partitions, since both disrupt the communication station operations. In the interim stage, the activities that will be located in the final solution as auxiliary communications activities should be housed on other floors in the total multistory building.


Sperry
LDMX 70/45
MESSAGE center
Traffic Analysis
Mens Head
Womens Head
Mens Head
Sperry
NAVTASC
0
5
1
10

THIRD FLOOR BLDG 1 NSC SAN DIEGO
BEFORE

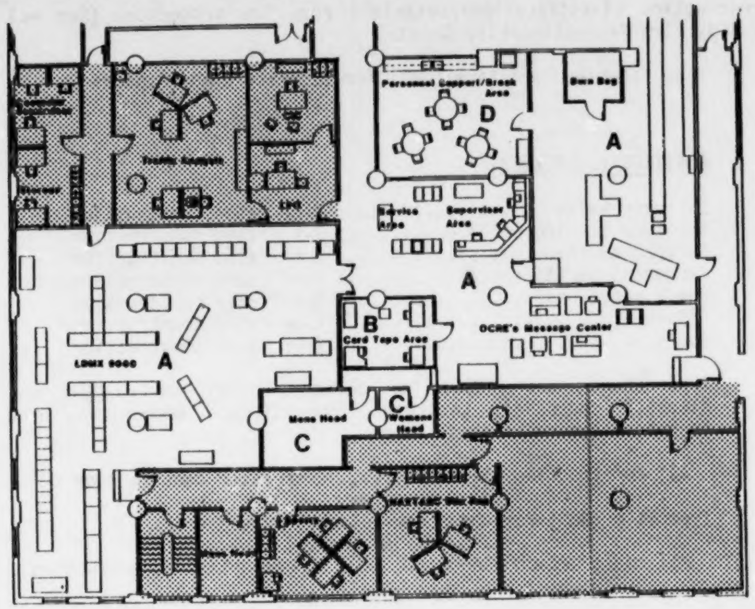

LDMX 70/45
Message Center
LDMX 90/60
Mens Head
Womens Head
Clerk
Message Center Officer
Mens Head
SPERRY
NAVTASC Site Rep
LDMX Officer
NTCC OIC
0
5
1
10

THIRD FLOOR BLDG 1 NSC SAN DIEGO
INTERIM


Computer Supervisor
Storage
Traffic Analysis
CIC
LPO
Personnel Support/Break Area
Burn Bag
Service Area
Supervisor Area
LDMX 9060
Card Tape Area
OCRE's Message Center
Mens Head
Womens Head
Clerk
Message Center Officer
NAVTASC Site Rep
Sperry
Mens Head
LDMX Officer
NTCC OIC
0
5
1
10

THIRD FLOOR BLDG 1 NSC SAN DIEGO
AFTER

guidance 1 Efficiency of Operational Functions


Personnel Support/Break Area
D
Bus Bay
A
Traffic Analysis
LPO
Storage
Service Area
Supervisor Area
A
B
Card Tape Area
DCRE's Message Center
LDMX 9000
A
Mens Head
C
C
Womens Head
Sperry
NAVTASC Site Rep

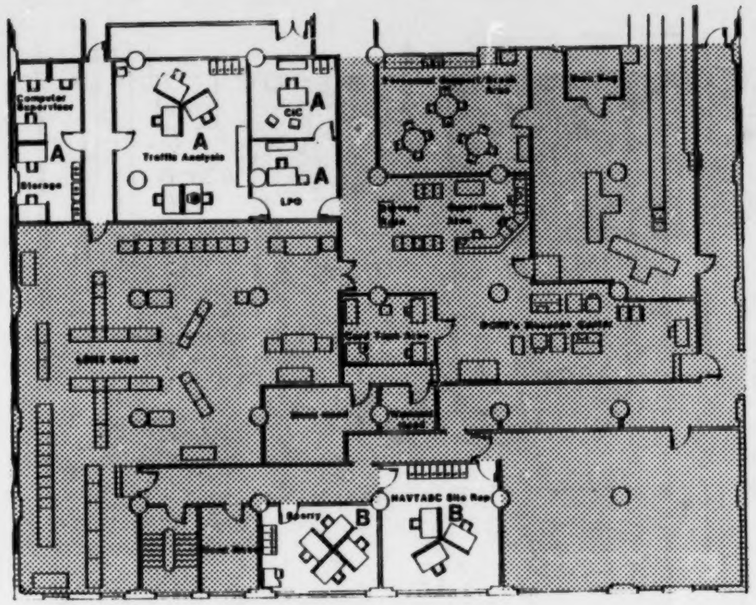
A Equipment is aligned in parallel rows in the LDMX 90/60 areas and distribution room for easy visual surveillance and direct access to all critical equipment. Multiple LDMX consoles are adjacent to each other so that limited personnel can monitor them efficiently from one central location. Tables for audiovisual training aids are available so that personnel can train on the job during regular watch periods.

B Additional spaces that have a close functional relationship to the LDMX operations activities are located adjacent to the operations spaces.

C Personnel in the operations spaces have easy access to toilet facilities.

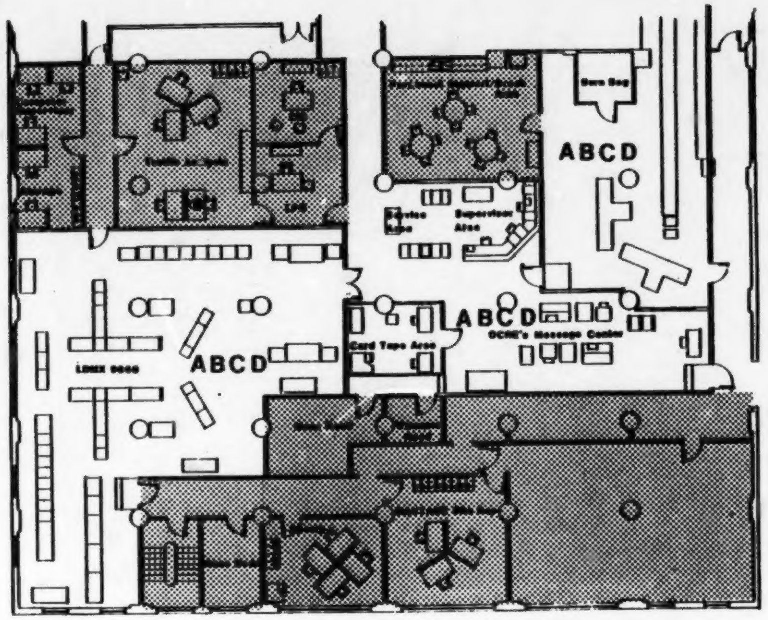
D The intense activities in this communication station tend to generate personnel mental fatigue. It is therefore necessary to create a change of environment for on-duty personnel as a break from the hard-surface equipment room and work areas. The personnel support/break area space is directly adjacent to the LDMX operations spaces, but is isolated acoustically and visually.

guidance 2 Efficiency and Accessibility of Admin Spaces


Computer Supervisor
A
Storage
A
Traffic Analysis
A
OIC
A
LPO
Sperry
B
NAVTASC Site Rep
B

A Administrative personnel are located for easy access by the public to minimize circulation and prevent visitor interference with LDMX operations. The administration spaces provide a buffer and transition space between the exterior and secure interior spaces.

B DCS personnel and equipment manufacturer representatives are integrated with the operational spaces to improve efficiency by minimizing normal operational circulation distances.



Occupancy classifications: Business (NFPA); B-2 (UBC)

Hazard of contents classification: Ordinary hazard

Sprinkler protection classification: Ordinary hazard--group 2

Construction classifications/materials for fire protection (See Vol 2, SB3, Fire Protection/Life Safety)

Type II--Fire resistive (UBC) for security/armory spaces

CONSTRUCTION ELEMENT

CONSTRUCTION ELEMENT	
Exterior walls	4-hr rated construction
Interior bearing walls	2-hr rated construction
Structural frame	2-hr rated construction
Permanent partitions	1-hr rated construction
Shaft enclosures	2-hr rated construction
Floors	2-hr rated construction
Roofs	2-hr rated construction

A Type II--one-hour (UBC) for battery, cryptography (Red and Black),* custodial, generator, operations,* mechanical, and technical control spaces

All construction elements....... 1-hr rated construction

Type II-N (UBC) for the other building spaces

All construction elements....... Noncombustible construction

Building separation

Site-specific information is required. Comply with Vol 2, SB3, Fire Protection/Life Safety.

Interior finishes

See Guidance/Life Safety.

Fire protection systems

Automatic fire suppression:

A water sprinkler system shall be provided throughout the facility.

B Halon 1301 or carbon dioxide system shall be provided under all raised floor areas containing nonmetallic sheathed, exposed cables when the space under the raised floor is used as an air plenum.

Automatic notification/alarm:

General alarm activated by the automatic sprinkler system.

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*See Vol 2, SB7, Security, for vault construction requirements that may be more stringent than those imposed by fire protection requirements.

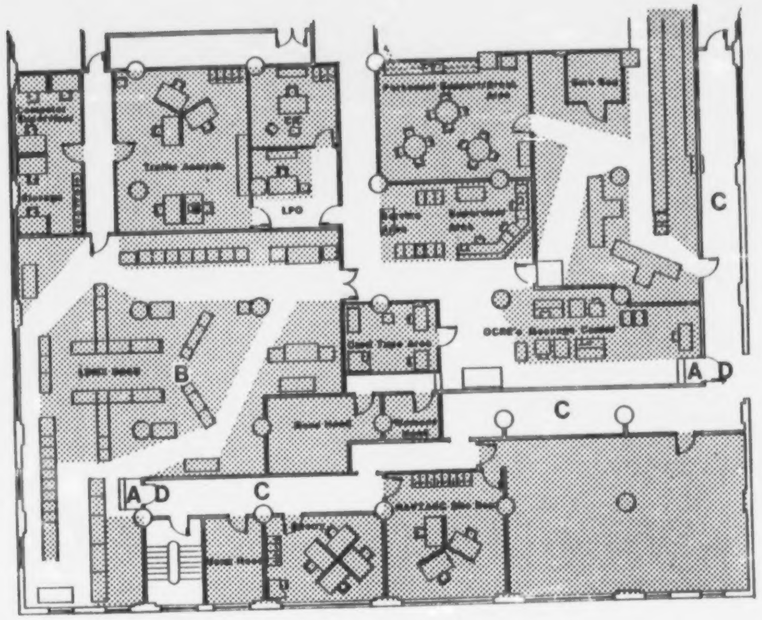
guidance **3.**

C Local alarm to sound in these spaces only, activated by smoke detectors.

Automatic fire detection

D Smoke detectors to activate local alarms in these spaces only. In rooms containing raised floor areas, smoke detectors shall be located under the raised floor.

guidance



Exit capacities

Corridors: 100 persons per unit of exit width for traveling either direction. The minimum width of any exit access corridor or passageway shall be 44 inches in the clear.
Doors: 100 persons per unit of exit width (a 3-foot door provides 1-1/2 units of exit width, providing exit capacity for 150 persons).

Number of exits

No less than two exits shall be accessible from every part of every floor. A single exit is permitted when the room or area has (1) a total occupant load of less than 100 persons, (2) direct exit to an open area outside the building at the ground level, and (3) a total travel distance on the same level of no more than 100 feet. (If stairs are involved, they shall be no more than 15 feet high and shall be provided with complete enclosures to separate them from all other building parts.

Exit travel distances

Required exits shall be located to allow access without passage through areas subject to locking. No dead-end corridor shall exceed 50 feet. The travel distance to exits shall be no more than 300 feet when the building is protected throughout by an approved automatic sprinkler system.

Arrangement of means of egress

Exit access and travel routes to exits are shown in the plan.

A Exit doors in vaulted areas containing communication system equipment are secured and permit exits only. Exit access routes through vaulted areas from spaces outside these areas are not permitted for security reasons.

B Two means of egress shall be provided from higher hazard areas, including mechanical and generator spaces. Exit access from any other space may not pass through mechanical or generator spaces (see exit marking). For security reasons, when mechanical or generator spaces have exit access routes through interior spaces, exit access doors from these spaces, when opened, shall sound an alarm and transmit a signal to the annunciator panel in the security space. Access for normal maintenance in mechanical and generator spaces shall be through the exterior doors.

Interior finishes

C Interior finishes in exit access corridors shall be Class A only.

Interior finishes in the remainder of the building shall be Class A or B only.

guidance 4

Illumination of means of egress

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Marking of means of egress

Exits shall be marked by an approved sign readily visible from any direction of exit access. Sign placement shall be such that no point in the exit access is more than 100 feet from the nearest visible sign.

D Doors located or arranged so they are likely to be mistaken for exits shall be identified by a sign reading "NOT AN EXIT".

guidance

DCS SITE SURVIVABILITY PROJECTS

(SS)

DCS SITE SURVIVABILITY PROJECTS SS

1 Monte Vergine, Italy SS-3
2 Seoul, Korea SS-9
3 Feldberg, FRG SS-13

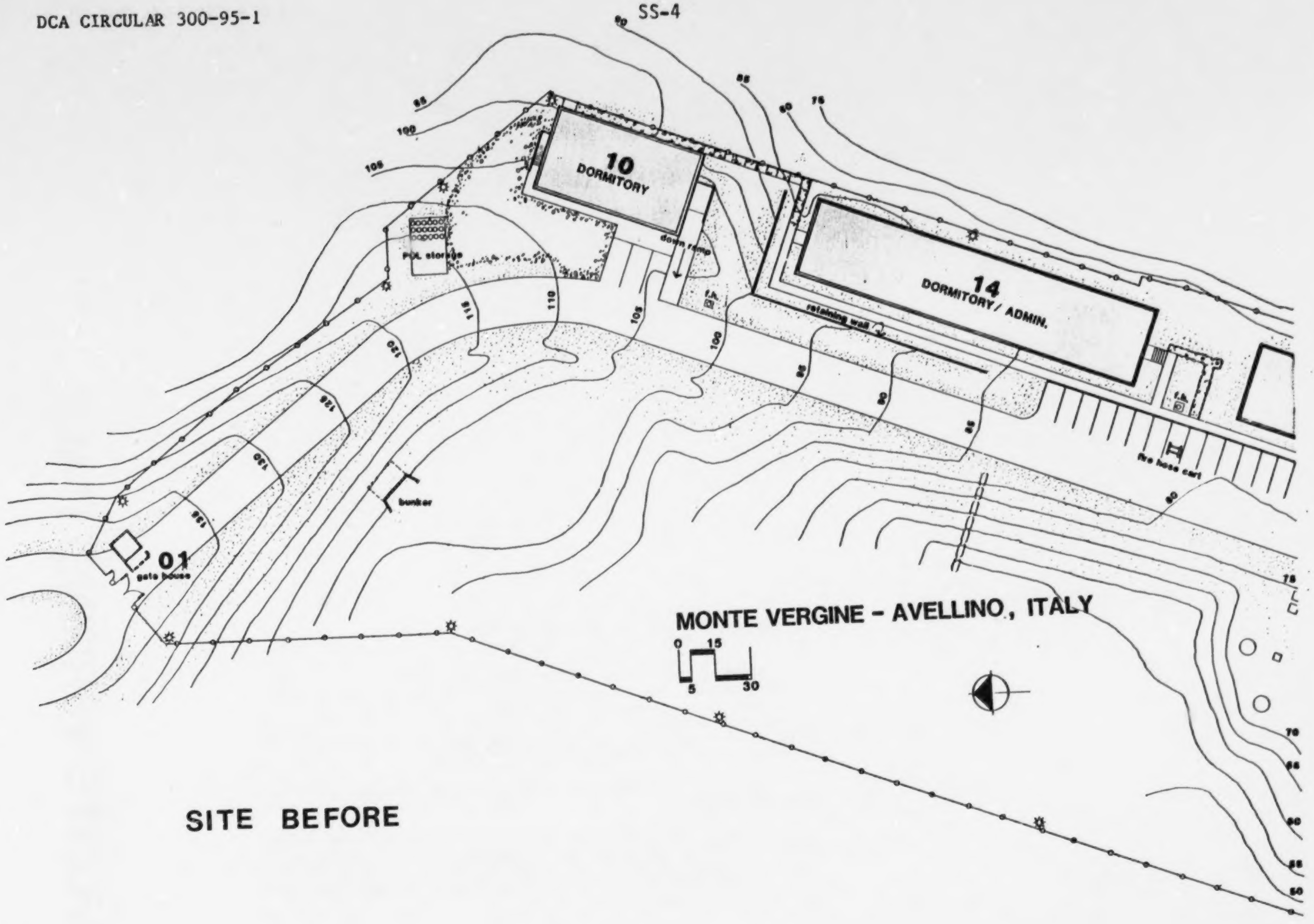
MONTE VERGINE, ITALY

DCS Site Development for Improved Survivability
and Pollution Abatement

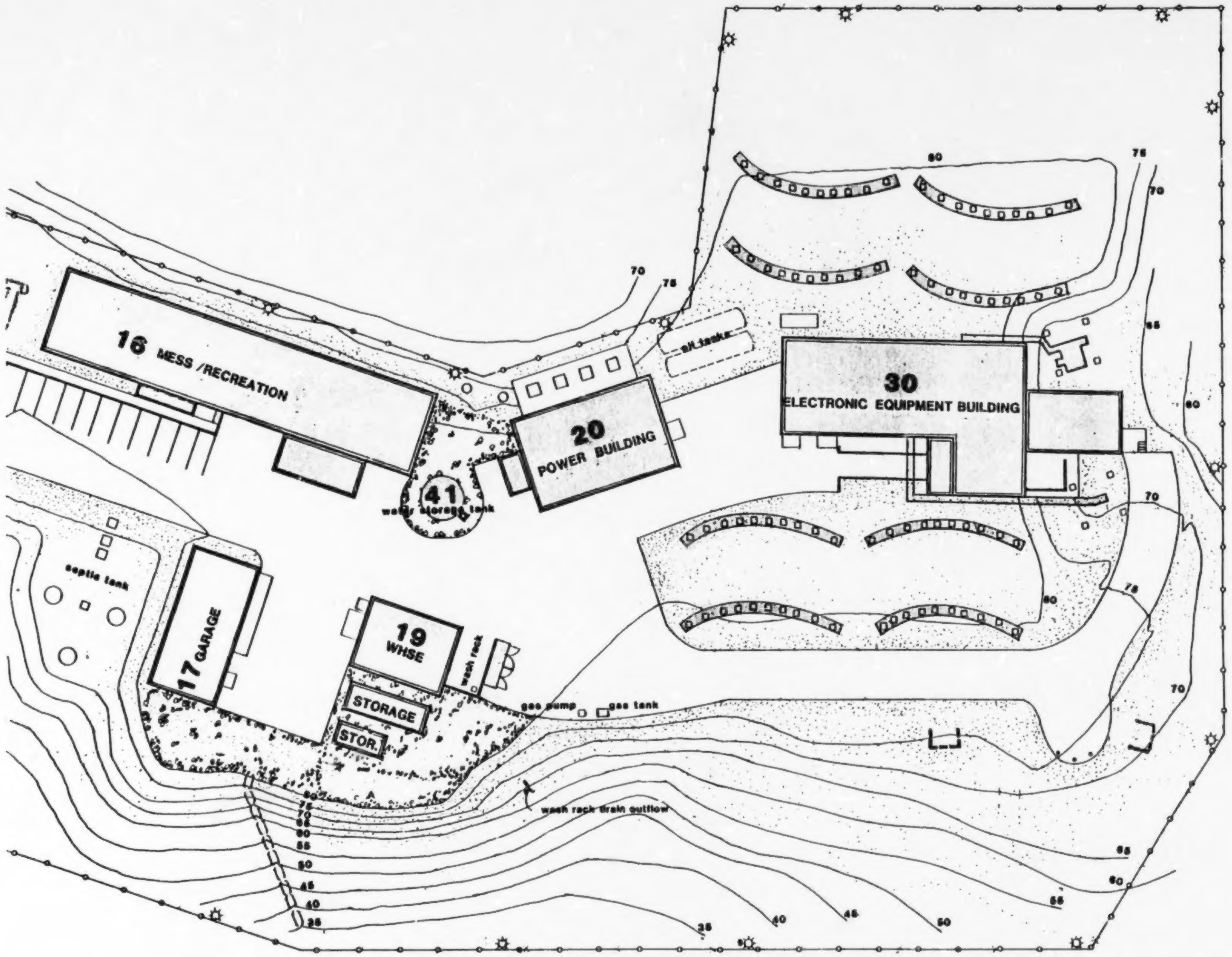
GIVEN: This is a multibuilding communication station at a remote site on a mountaintop, several miles from any military installation or other defense-oriented facility. The station consists of 12 buildings with two at the south end of the site related specifically to communication and power requirements. All antennas are adjacent to the electronic equipment building.

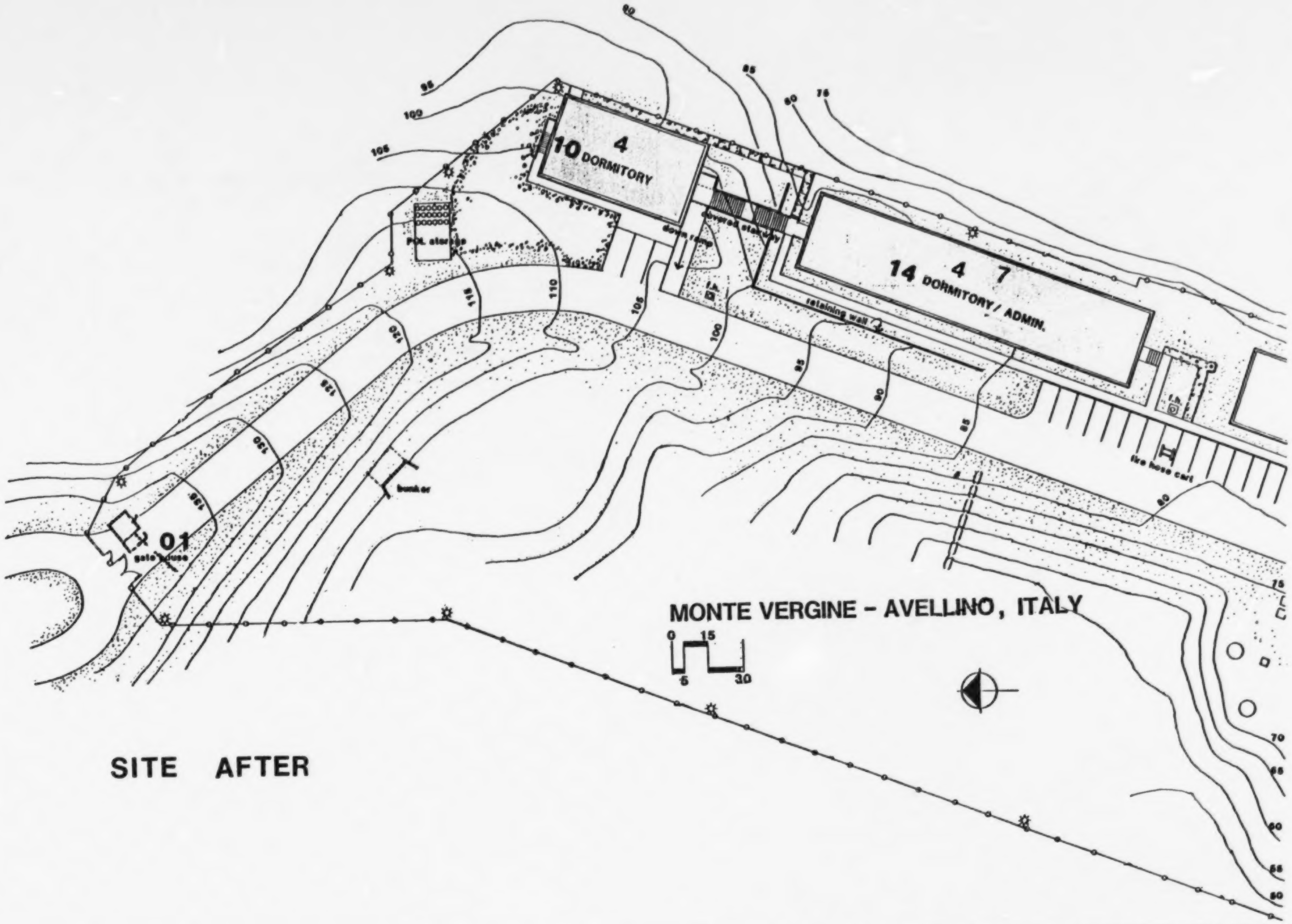
OBJECTIVE: The retrofit objective is to reinforce the site's communication security.

ACTION: The communication and power-related buildings and all antennas will be surrounded by an additional security fence and an improved lighting system. All buildings will be repainted to blend with the landscape colors. Also, three measures for pollution abatement will be included.


10
DORMITORY
14
DORMITORY / ADMIN.
POL storage
down ramp
f.h.
retaining wall
fire hose cart
bunker
01
gate house
MONTE VERGINE - AVELLINO, ITALY
0
15
5
30

SITE BEFORE

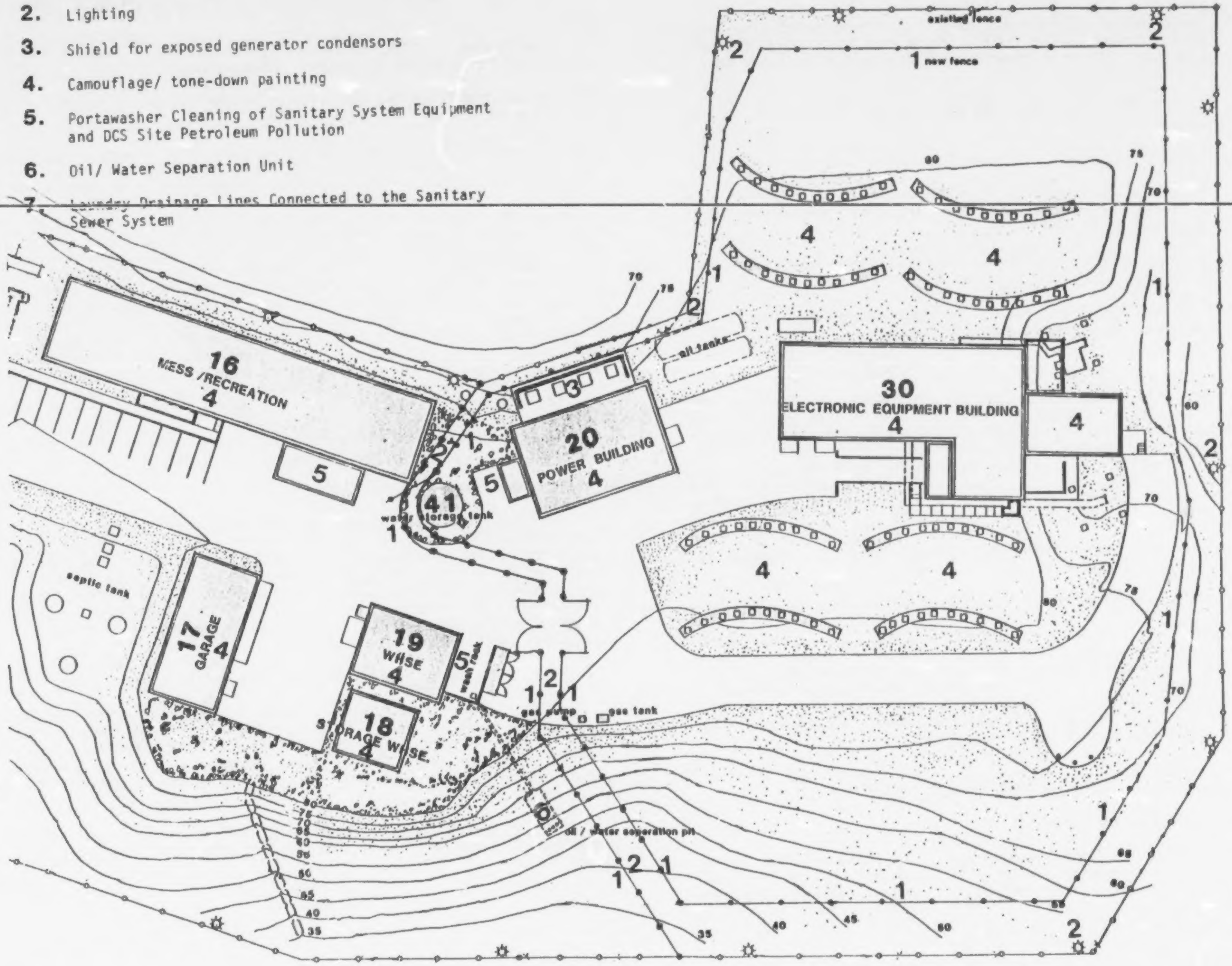

16 MESS /RECREATION
20 POWER BUILDING
30 ELECTRONIC EQUIPMENT BUILDING
41 water storage tank
oil tanks
septic tank
17 GARAGE
19 WHSE
wash rack
STORAGE
STOR.
gas pump
gas tank
wash rack drain outflow
80
75
70
65
60
55
50
45
40
35


10
4
DORMITORY
14 4 7
DORMITORY / ADMIN.
POL storage
down ramp
covered stairway
retaining wall
bunker
01
gate house
fire hose cart
MONTE VERGINE - AVELLINO, ITALY
0
15
5
30
80
85
90
95
100
105
110
115
120
125
130
135
75
70
65
60
55
50

SITE AFTER

SITE IMPROVEMENTS

1. Security Fencing
2. Lighting
3. Shield for exposed generator condensors
4. Camouflage/ tone-down painting
5. Portawasher Cleaning of Sanitary System Equipment and DCS Site Petroleum Pollution
6. Oil/ Water Separation Unit
7. Laundry Drainage Lines Connected to the Sanitary Sewer System


existing fence
1 new fence
16 MESS /RECREATION 4
20 POWER BUILDING 4
30 ELECTRONIC EQUIPMENT BUILDING 4
41 water storage tank
17 GARAGE 4
19 WHSE 4
18 STORAGE WHSE. 4
oil tanks
septic tank
gas pump
gas tank
oil / water separation pit
1
2
3
4
5
6
70
75
80
65
60
55
50
45
40
35

1. Security fencing

The new fencing is erected parallel to the existing site perimeter fence surrounding the site's south end to provide a double security barrier. It is recommended to achieve the following security objectives:

a. Assist in controlling unauthorized entries into a secured area.

b. Support detection, assessment, and other security functions.

c. Deter casual intruders from penetrating into a secured area or cause an intruder to take some overt action that will demonstrate his/her intent.

d. Briefly delay access to a secured area or to construction facilities adjacent to secured areas.

(See Volume 2, SB7, Security Systems, Security/2 Zone 1 for detailed guidance on perimeter security fences.)

2. Lighting

The new site lighting system is erected between the new and existing fence as a "standby lighting system." A standby system was recommended rather than continuous lighting to create an impression of activity. The luminaires are not lighted continuously, but are turned on automatically at random or when the detection system sensors show suspicious activity. Lamps with short restrike times are required. This type system offers good deterrent value as well as economy in power consumption.

(See Volume 2, SB7, Security Systems, Security/3 Zone 2 for detailed guidance on perimeter security lighting.)

3. Shielding exposed generator condensors

The four generators in the power building (20 in the figure) require cooling radiators to function properly. Protective shields are needed to prevent the easy destruction of these radiators by hostile small-arms fire. "Hiding" the cooling units behind an enclosure will contribute greatly to the radiators' survivability. In addition, the enclosure shields will be considered "protective walls" to provide resistance against small-arms projectiles.

(See Volume 2, SB8, Survivability Protection, Attack Threats/1 Revetments for detailed guidance on protective walls.)

4. Camouflage/tonedown painting

The buildings, antennas, and certain site features (such as the water tank and fuel pumps) will be camouflaged by blending their surface colors with the site's natural background colors. The main colors used will be earth yellow, light green, dark green, and forest green.

(See Volume 2, SB8, Survivability Protection, Attack Threats/2 Camouflage for detailed guidance on tonedown painting.)

5. Portawasher cleaning of sanitary system equipment and DCS site petroleum pollution

One requirement for solid-waste management at a remote DCS site is an efficient method for cleaning sanitary system containers. For example, regulations require that dumpster containers be cleaned regularly to maintain general sanitary conditions and to prevent nuisances. At remote DCS sites, equipment is needed to clean dumpster containers onsite rather than at a central cleaning location. This DCS site should obtain a Portawasher unit for general sanitary systems cleaning requirements. The Portawasher is suited for cleaning containers, structures, washrack areas, POL transfer areas, and other essentially immovable property onsite, particularly when the recovery of the washwater is important. The Portawasher can be used for cleaning administrative-type vehicles and equipment when permanent washing facilities are not available. The vacuum recovery system can be used to service portable latrines, recover liquid spills, empty tanks, or for any operation involving liquid or sludge transfer at the DCS site.

(See Volume 2, SB1, Site Planning and Development--Wastewater Impact/1 for complete information on the Portawasher.)

6. Oil/water separation unit

This DCS site uses several vehicles that need petroleum product servicing and routine washing. Both activities result in petroleum pollution of the environment unless an oil/water separation unit is installed in all site drainage systems that carry surface water from the washing and servicing areas. This DCS site should install a separation unit to eliminate the current petroleum pollution problem. The Portawasher discussed in item 5 above can be used periodically to flush out the oil/water separator unit.

7. Laundry drainage lines connected to the sanitary sewer system

Site personnel have several clothes washers and dryers in the dormitory/medical building (14 in the figure). The washwater drains were not connected to the septic tank system (15). Therefore, this DCS site should connect the washwater drainage line to the sanitary sewer system to eliminate detergent and soap products from the surface water.

(See Volume 2, SB1, Site Planning and Development--Wastewater Impact/2 for detailed information on sanitary sewer treatment systems.)

SEOUL, KOREA

Nam San DCS Site Development for Survivability Improvements

GIVEN: This is a multibuilding communication station on a hilltop near a major metropolitan area. The station consists of eight buildings with two at the site's northwest end devoted to communication and power equipment. The line-of-sight (LOS) microwave (MW) antenna tower is adjacent to the communication equipment building. The site is completely surrounded by a double fence.

OBJECTIVE: The objective of a survivability upgrade is to improve the site's defensive positions by including a series of perimeter fire-port bunkers that will allow complete surveillance over the entire length of fencing. In addition, this site retrofit should include a concrete revetment around the existing communication and power buildings to make the site more defensible against a small-group terrorist attack. Also, all buildings and the LOS MW tower need lower visibility, perhaps by repainting to blend with the surrounding natural landscape colors.

1. Fire-port bunkers

The purpose of the fire-port bunkers' layout is to: cover enemy avenues of approach, create distinct fields of fire, and provide mutual support. Siting is important to bunker efficiency. These bunkers are used mainly for defense against ground attack and thus are located to cover avenues of approach and provide the best fields of fire. This siting layout shows the bunkers with extensive overlap of fields of fire, a condition necessary for an effective system. The bunkers shown are composed of reinforced concrete "logs" stacked and interlocked with each other. The logs are modular and can be made easily at this remote site if equipment is available to lift them into place.

(See Volume 2, SB8, Survivability Protection, Attack Threats/5 Bunkers for detailed guidance on fire-port bunkers.)

2. Revetments

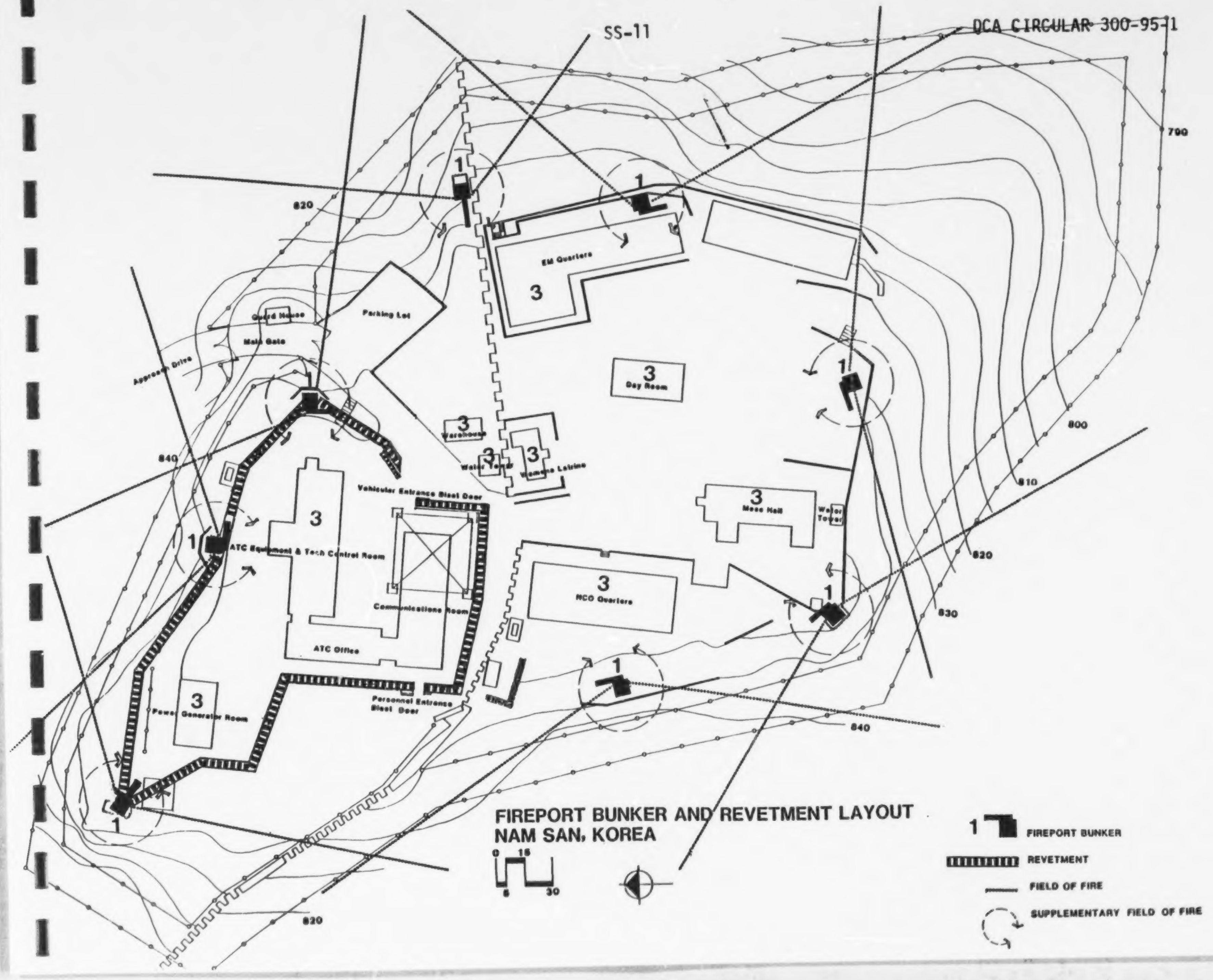
Revetments primarily provide protection against small-arms fire, near-miss blasts, and minimal direct hits, thus greatly increasing facility hardness and portions therein. System selection depends on factors such as materials availability, cost, construction effort, repair effort, design flexibility, permanency, and degree of threat. Based on these factors, the revetment type selected is a massive gravity wall, 6 feet thick at the groundline and 4 feet thick at the top.

(See Volume 2, SB8, Survivability Protection, Attack Threats/1 Revetments for detailed guidance on site revetments.)

3. Camouflage/tonedown painting

The buildings, antennas, and certain site features (such as the water tank and fuel pumps) will be camouflaged by blending their surface colors with the site's natural background colors. The main colors used will be earth yellow, light green, dark green, and forest green.

(See Volume 2, SB8, Survivability Protection, Attack Threats/2 Camouflage for detailed guidance on tonedown painting.)


790
820
800
810
820
830
840
840
820
Guard House
Main Gate
Approach Drive
Parking Lot
EM Quarters
3
Day Room
3
Warehouse
3
Water Tower
3
Womens Latrine
3
Mess Hall
3
Water Tower
NCO Quarters
3
ATC Equipment & Tech Control Room
3
Vehicular Entrance Blast Door
Communications Room
ATC Office
Power Generator Room
3
Personnel Entrance Blast Door
1
1
1
1
1
1
1
1
0
15
5
30
1
FIREPORT BUNKER
REVETMENT
FIELD OF FIRE
SUPPLEMENTARY FIELD OF FIRE

FIREPORT BUNKER AND REVETMENT LAYOUT
NAM SAN, KOREA

FELDBERG, FRG

Site Development for Survivability and DCS Reconfiguration/
Reconstitution Vans

GIVEN: This is a remote multibuilding DCS communication facility on a hill in the country. Because of host nation constraints on land availability, the total site security perimeter fence is very close to the communication buildings. Also, there is very limited space between the existing buildings for vehicle circulation. The site is extremely compact with possibly vulnerable perimeter conditions.

OBJECTIVE: The objective of this retrofit is to improve the communication system survivability by installing a revetment around the station's communication and power buildings and lower sections of the line-of-site (LOS) microwave (MW) antenna tower. Another goal is that fire-port openings be integrated into the revetment walls. The retrofit thus would need to deal with the limitation of available site area by integrating the defensive fire-port openings into the revetment structure. Also, all buildings and the LOS MW tower need lower visibility, perhaps through repainting to blend with the surrounding natural landscape colors.

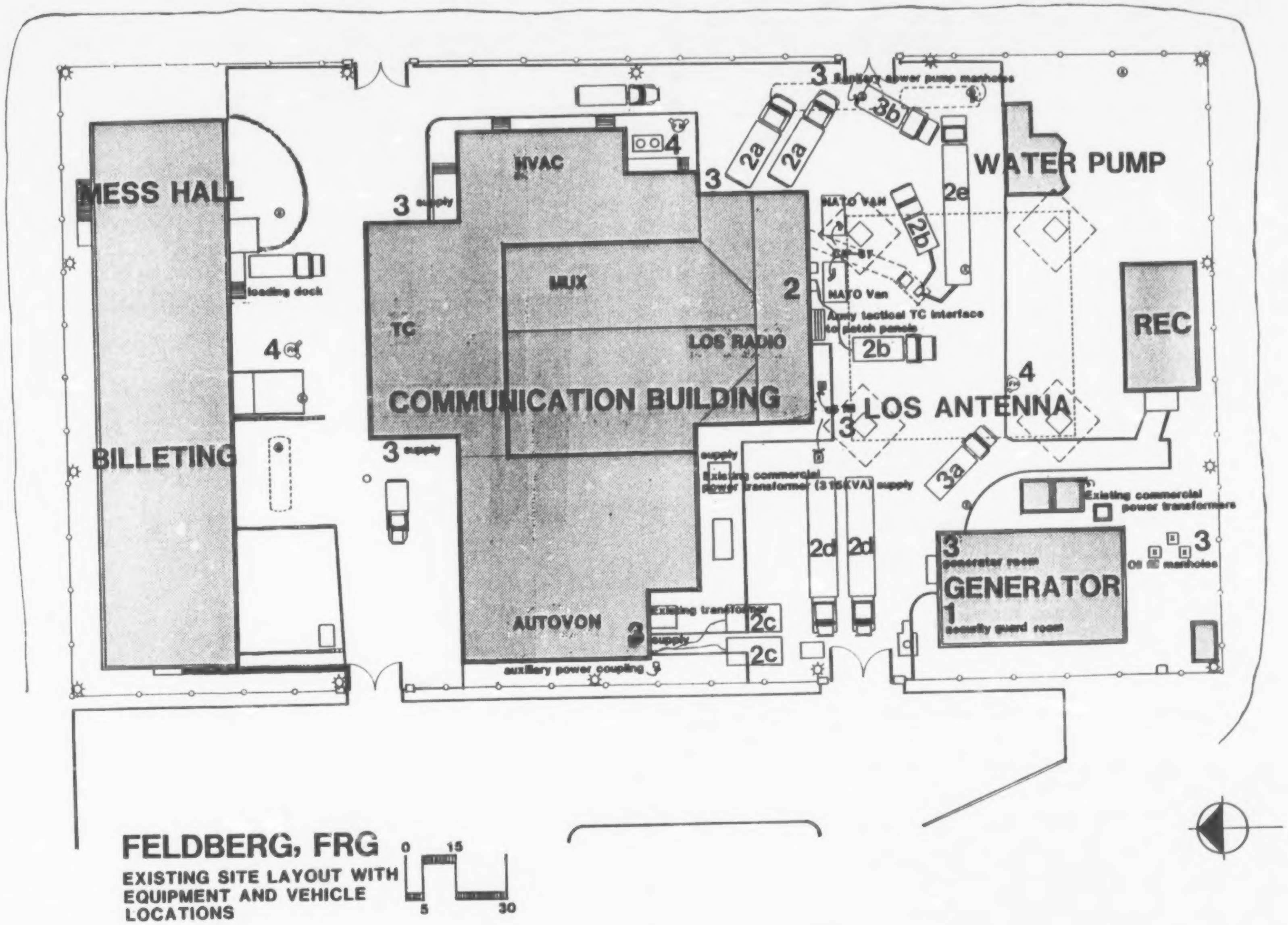
Two competing schools of thought on DCS survivability nevertheless support the development of DCS reconfiguration/reconstitution vans prepositioned in hardened storage bunkers. (See the reconfiguration/reconstitution shelter section in this volume.) The first presupposes destruction of most DCS fixed assets at the outset of hostilities, thus placing the burden of command and control communications responsibility on transportable equipment. The second school takes a more optimistic perspective, suggesting that cost-effective steps can be taken to enhance the survivability of fixed sites so that a large percentage of them could remain operational at some level. For damage that inevitably would be experienced, prepositioned reconstitution packages are proposed to permit restoration of critical links and service. The items listed below under 2c, 2d, and 2e (and also the vans identified on the following site plan) are related to the reconstitution requirements for a typical site. The revetment layout and the required shielded openings for vehicle and personnel access are based on the following four categories of DCS site requirements:

1. Site and building security/survivability
    a. Shield communication related structures
        (1) Communication building
        (2) Power generation building
        (3) Tower base
    b. Maintain gate guard activities
    c. Provide personnel fireports (or bunkers).

2. Communication mission activities
    a. NATO communication exercises
    b. Tactical communication exercises (REFORGER)
    c. Power reconstitution
    d. Signal reconstitution
    e. Antenna reconstitution.

3. Site supply and maintenance activities
    a. POL delivery
    b. Sanitary sewer pumpout
    c. Emergency water delivery
    d. Access to building double-doors.

4. Fire safety
    a. Access to fire hydrants
    b. Access to buildings.


MESS HALL
loading dock
BILLETING
4
3 supply
3 supply
HVAC
4
3
MUX
TC
COMMUNICATION BUILDING
LOS RADIO
AUTOVON
3
Existing transformer
supply
2c
2c
auxiliary power coupling
2
3 Sanitary sewer pump manholes
2a
2a
3b
2e
WATER PUMP
NATO VAN
NATO Van
2b
Army tactical TC interface to patch panels
2b
LOS ANTENNA
3
4
REC
3a
supply
Existing commercial power transformer (315KVA) supply
2d
2d
Existing commercial power transformers
3
generator room
GENERATOR
1
security guard room
3
Oil manholes
0
15
5
30

FELDBERG, FRG

EXISTING SITE LAYOUT WITH EQUIPMENT AND VEHICLE LOCATIONS

MILITARY CONSTRUCTION PROJECT DATA (as required on DD Form 1391)

Description of proposed construction: this project provides for the construction of a new fence revetment around the tower and some buildings, a master key system and locks, a parking area outside the new fenceline, and a decontamination station.

requirements

Requirement

Make site and building modifications.

Project

Work to be done includes:

a. New parking areas outside the outer fenceline, 2738.1 square yards.

b. Tonedown painting of tower and buildings.

● c. REVETMENT, REINFORCED CONCRETE, 16 INCHES THICK, 20 FEET HIGH, AROUND TOWER AND BUILDINGS (393.4 linear yards).

d. Master key system and locks for all buildings and gates. Manhole cover locks will have their own master key system.

e. New security fence as shown in the design, including vehicle entry and personnel gates (437.6 linear yards).

f. Innermost fence surrounding technical facility (207.8 linear yards).

g. Tree removal.

h. "Restricted Area" signs (13).

i. All windows blocked in existing technical facility.

j. New paved area in front of the dormitory/dining hall (476.2 square yards).

k. New paved area along the fence at the technical facility (59.5 square yards).

l. A 1.5-inch water line extending 21.9 linear yards.

m. A 4-inch water line extending 10.9 linear yards.

requirements

n. One new diesel fuel double-wall underground storage tank, 52.8-gallon capacity.

o. Special filtration requirements for CBW protection of:

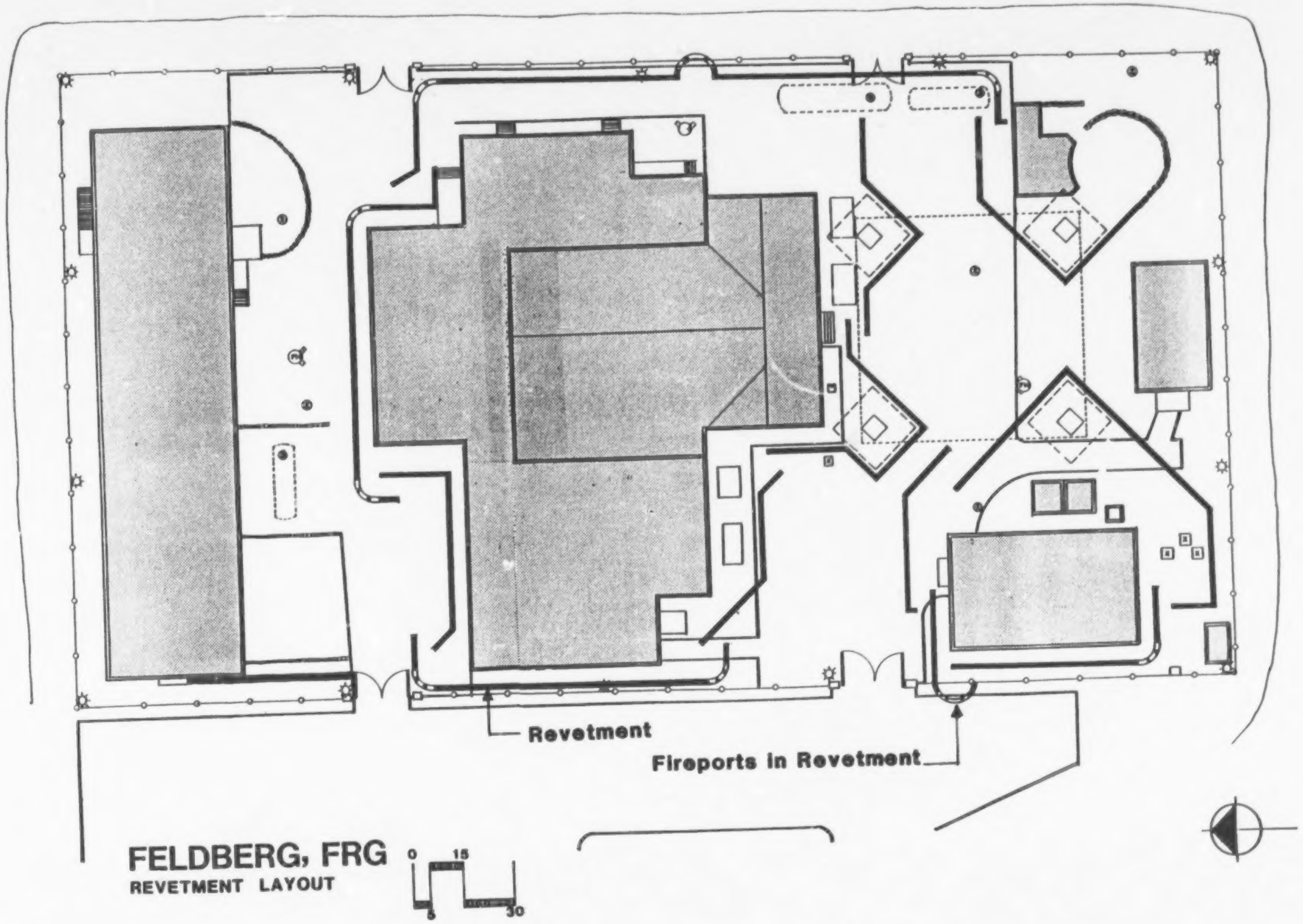
1. AUTOVON, 10-person capacity (106 cubic feet per minute).

2. Air-conditioning in the technical control area, 20-person capacity (212 cubic feet per minute).

3. Ventilation system, 20 person capacity (212 cubic feet per minute).

p. Emergency storage tank for water, 1900-gallon capacity.

q. Emergency sewage storage tank in concrete, 1900-gallon capacity.


Revetment
Fireports in Revetment
0
15
5
30

FELDBERG, FRG
REVETMENT LAYOUT

DCS NEW CONSTRUCTION PROJECTS
(NC)

DCS NEW CONSTRUCTION PROJECTS **NC**

1 Woensdrecht, NL NC-3
2 Kamiseya, Japan NC-15
3 Camp Carroll, Korea NC-27

WOENSDRECHT, NL

New Construction DCS Building and Site Development

GIVEN: This facility is a new construction project that will be part of the Digital European Backbone (DEB) DCS improvement program in Europe. Project funding is through a Military Construction (MC) program requiring complete justification and scope documentation on DD Form 1391. This project is targeted for location on a military installation outside the Continental United States (OCONUS). Since there usually are U.S. military personnel assigned to a host-nation base, indoor recreational, laundry, and personnel support activities must be located in this building. The facility should be designed so that assigned personnel can use these other spaces without interfering with normal DCS operations. Larger-than-normal personnel support areas and additional recreation and laundry spaces should be included. In addition, the training/library space is intended to serve as a recreational movie room so that off-duty personnel can view movies independently and use the space when it is not scheduled for official use. Otherwise, the other communication, power, and administrative spaces should be like those in conventional OCONUS DCS facilities.

Case Study 1
Woensdrecht, NL

Air Force

EXISTING FACILITIES/DEFICIENCY DETAIL DATA

Scope of FY85 Request: 6300 square feet

Requirement Computations

MISSION: The Digital European Backbone (DEB) mission is to provide a microwave relay system, which is required as the primary defense communication system for U.S. Armed Forces in Europe.

REQUIREMENT: 6300 square feet are required to house digital communication and technical control equipment and emergency generators. AFM 86-2 provides no specific requirement for this category code item.

Requirements/Assets

		Scope (sq ft)	No. of Bldgs.
a.	Total requirement	6300	1
b.	Existing substandard	0	
c.	Existing adequate	0	
d.	Funded, not in inventory	0	
e.	Adequate assets (c+d)	0	
f.	Unfunded prior authorization	0	
g.	Included in prior FY programs	0	
h.	Deficiency (a-e-f-g)	6300	1

MILITARY CONSTRUCTION PROJECT DATA (as required on DD Form 1391)

Description of proposed construction: construct a new reinforced concrete building, slab-on-grade, with a pitched, built-up roof, to house the DEB communications equipment. Include the following necessary support facilities: electric, water, sanitary sewer, site improvement, fencing, pavements, underground fuel storage, hookups, and additional materials for Government-furnished engine-generators. The DEB communications building will include technical, mechanical, administrative, and domestic areas. Air-conditioning should support 15 t.

requirements

Requirement

Provide 6300 square feet.

Project

Construct new facilities to house and support the DEB communications equipment. This site uses both troposcatter and microwave transmission techniques. Site will also be a staging area for a mobile maintenance team that will service three unstaffed radio repeater sites in The Netherlands. This site is part of the fourth stage of a four-stage program and provides a vital new link for connectivity between Martelsham Heath, England, and Keizersveer, Netherlands (FY86 MCP).

Requirement

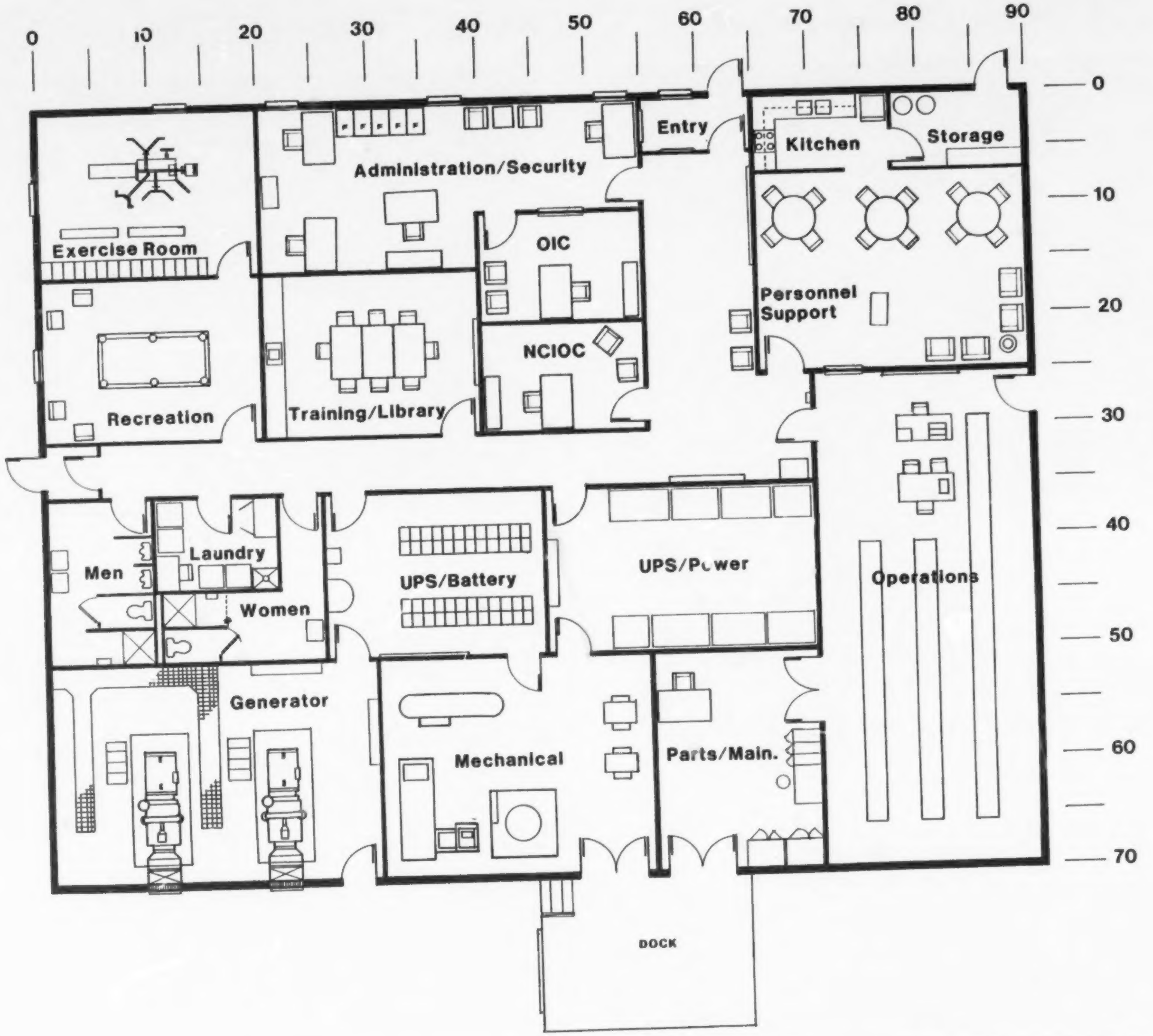
DEB is a microwave relay system required as the primary defense communication system for U.S. Armed Forces in Europe. It must be able to furnish rapid, reliable service on demand. This system of radio transmitters and receivers handles communication traffic in both voice and data modes. It serves all U.S. Forces in Europe either directly or indirectly.

Current Situation

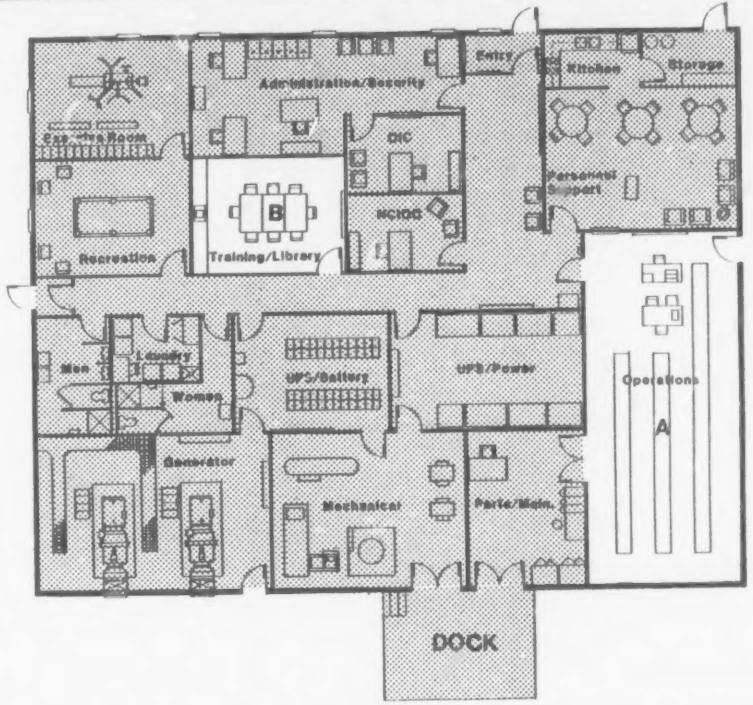
The current microwave communications system does not have a large enough channel capacity and is too insecure for transmitting classified information. The digital upgrade will increase channel capacity and reliability and provide secure communications for users in Europe.

Impact If Not Provided

Without this site, the vital new DEB link between Martelsham Heath, England, and Keizersveer, Netherlands, cannot be provided.


0
10
20
30
40
50
60
70
80
90
Entry
Kitchen
Storage
Administration/Security
Exercise Room
OIC
Personnel
Support
Recreation
Training/Library
NCIOC
Men
Laundry
Women
UPS/Battery
UPS/Power
Operations
Generator
Mechanical
Parts/Main.
DOCK
0
10
20
30
40
50
60
70

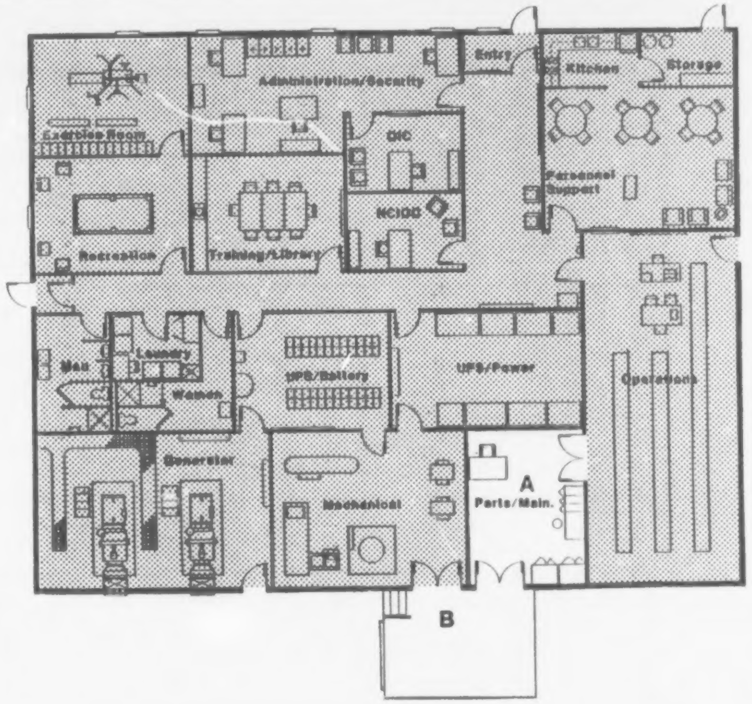
guidance 1 Efficiency of Operational Functions


Exercise Room
Administration/Security
Entry
Kitchen
Storage
OIC
Personnel Support
NCIOC
B
Training/Library
Recreation
Men
Laundry
Women
UPS/Battery
UPS/Power
Operations
A
Generator
Mechanical
Parts/Main.
DOCK

A Equipment is aligned in parallel rows in the operations module for easy visual surveillance and direct access to all critical equipment. The shift personnel tables are adjacent to each other so that limited numbers can work together efficiently at one central location. Audiovisual aids are available so personnel can train on the job during regular watch periods.

B To improve on-the-job training, small groups of four or five can be instructed in the training room.

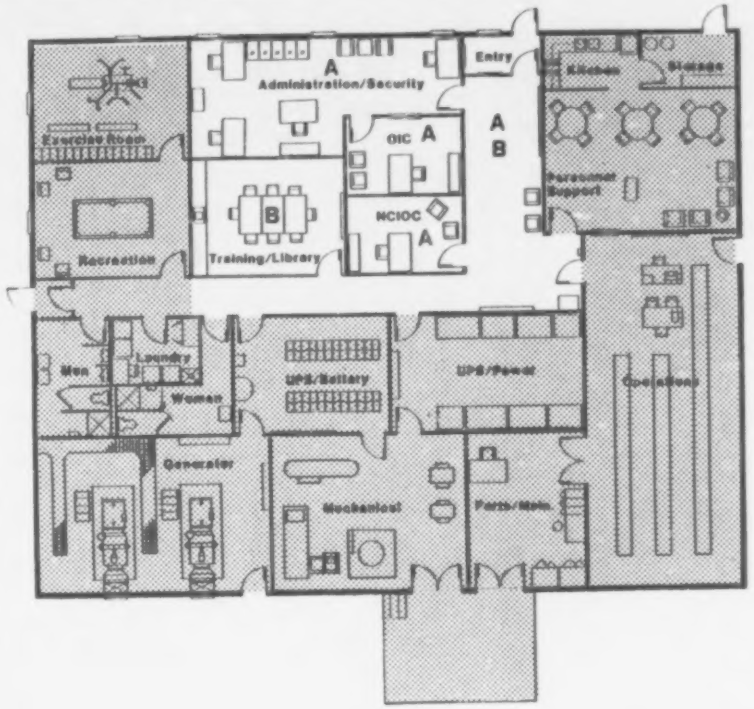
guidance 2 Integration of Parts / Maint Modules with Ops


Exercise Room
Administration/Security
Entry
Kitchen
Storage
OIC
Personnel Support
NCIOC
Training/Library
Recreation
Men
Laundry
Women
UPS/Battery
UPS/Power
Operations
Generator
Mechanical
A
Parts/Main.
B

A The parts/maintenance space is integrated and next to the operations space for optimal personnel efficiency and minimal circulation. The secure door between the operations and maintenance/parts spaces is used only as a fire exit and to bring communication equipment in and out via the loading dock. This door has opening hardware only on the secure side.

B The parts/maintenance space also is adjacent to the mechanical room so that deliveries can be made directly and securely to the total building at the loading dock. Large mechanical, electrical, and communication equipment can be moved in and out more easily using the common loading dock.

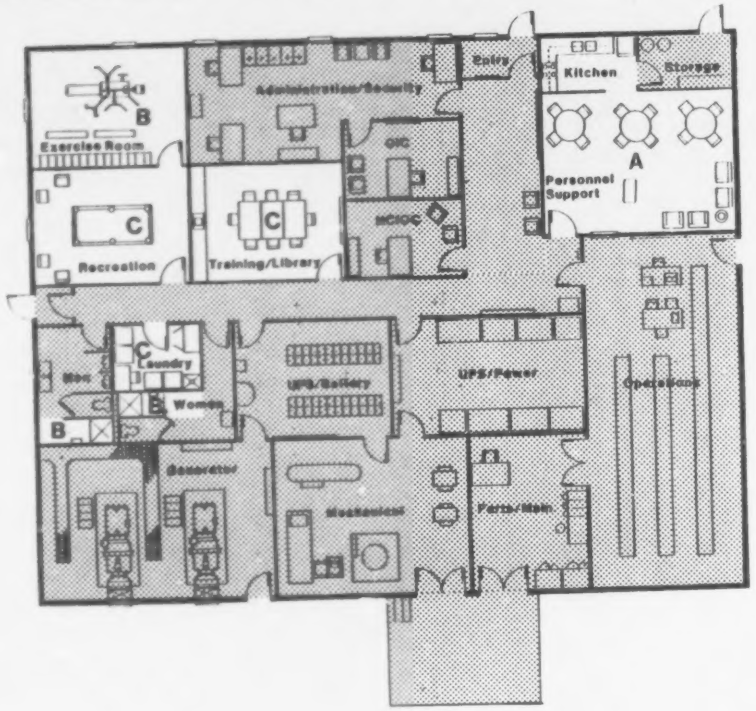
guidance 3 Efficiency and Accessibility of Admin Spaces


Exercise Room
Recreation
A
Administration/Security
OIC A
A
B
Entry
Kitchen
Storage
Personnel Support
B
Training/Library
NCIOC
A
Men
Laundry
Women
UPS/Battery
UPS/Power
Operations
Generator
Mechanical
Parts/Maint.

A Administration modules are located for easy access to the public to minimize circulation and prevent visitor interference with facility operations. The administrative spaces provide a buffer and transition area between the building exterior and the secure, DCS-related interior spaces. Also, public corridors in the administrative area are sized to contain military unit logos and other display panels that relate to the "esprit de corps" and the communication station's unit integrity.

B The administration rooms' integrated relationship is intended to improve efficiency by minimizing public and administrative circulation and by producing group adjacency to a shared conference area, waiting room, and secretarial work area.

guidance 4 Personnel Support Spaces

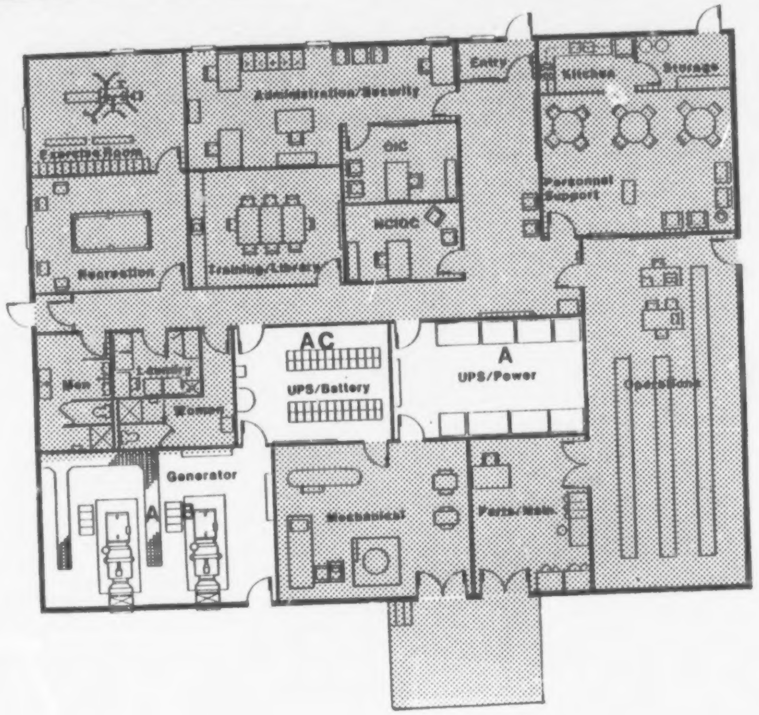

B
Exercise Room
C
Recreation
Administration/Security
C
Training/Library
OIC
NCIOC
Entry
Kitchen
Storage
A
Personnel Support
Men
C
Laundry
Women
B
UPS/Battery
UPS/Power
Operations
Generator
Mechanical
Parts/Maint.

A The intensive activities in the DCS operations space tend to generate personnel mental fatigue. It is therefore necessary to create a change of environment for on-duty personnel as a break from the hard-surface equipment room and work areas. The personnel support room is next to the operations room, but isolated acoustically and visually.

B Physical exercise equipment is provided for assigned personnel. This includes the necessary showers and lockers, which are located for easy access and optimal use.

C Since this facility is located on a host-nation military base, it includes three capabilities not usually required: a laundry, table game recreation area, and recreational movie presentation in the training/library. Personnel will have 24-hour access to these spaces to compensate for being at a remote site with limited amenities.

guidance 5 Integration Of Power / UPS Modules

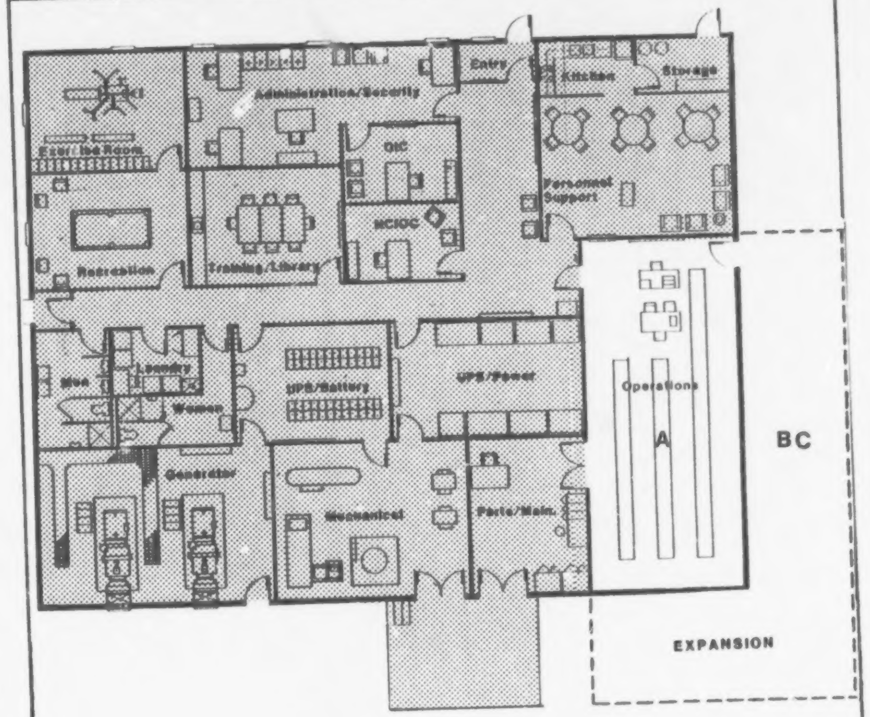

Exercise Room
Administration/Security
Entry
Kitchen
Storage
OIC
NCIOC
Personnel Support
Recreation
Training/Library
AC
UPS/Battery
A
UPS/Power
Operations
Men
Laundry
Women
Generator
A
B
Mechanical
Parts/Main.

A Modules comprising the power and uninterruptible power supply (UPS) capabilities are designed to be close together and well integrated. Direct physical adjacencies will provide economy by minimizing cable lengths and will increase personnel efficiency through interaccess relationships.

B Locating the generator space in a remote area will minimize the impact of noise vibrations on the communications transmission.

C The battery room ventilation will be energy-efficient since makeup air will be conditioned by being ducted through the mechanical room. Thus, the battery room interior ventilation supply air will be heated during cold weather. The exhaust will be vertical through the roof.

guidance 6 Facility Expansion

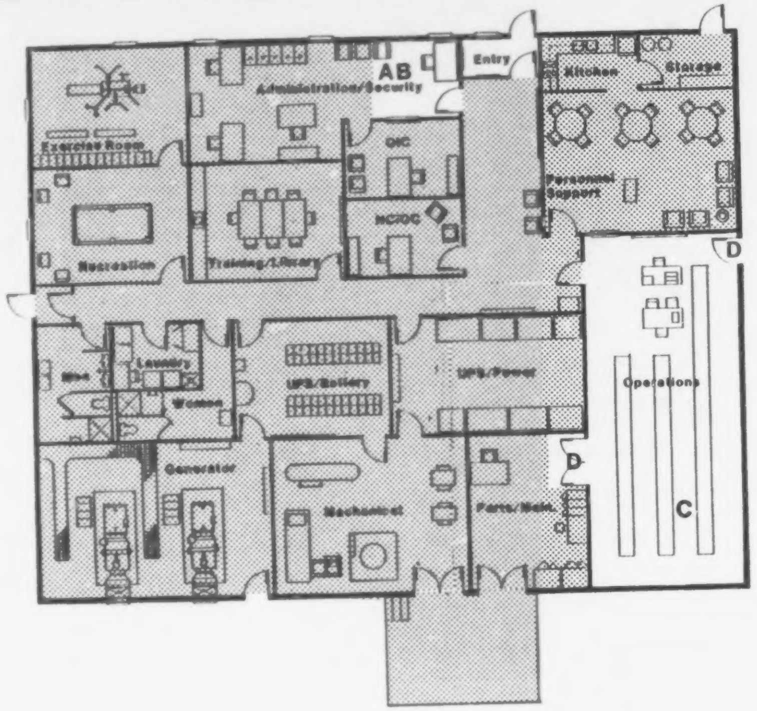

Exercise Room
Administration/Security
Entry
Kitchen
Storage
OIC
NCIOC
Personnel Support
Recreation
Training/Library
Men
Laundry
Women
UPS/Battery
UPS/Power
Operations
A
BC
Generator
Mechanical
Parts/Main.
EXPANSION

A The communication equipment layout is planned to allow enough space for installing equipment that can handle the maximum projected DCS traffic load. The initial equipment layout is such that the station transmission load can be expanded without rearranging already installed equipment. Space allowances for future equipment needs were estimated based on the requirements of similar missions.

B The operations room is functionally isolated from the administration, support, and power modules. Due to the increasingly rapid changes in communications technology, future demands on the operations room equipment layout can be expected. The layout must be expandable to accommodate new equipment and functions. Support and power spaces probably will not need this same expansion capability and therefore are located in their defined areas to allow operations room expansion without greatly affecting the remaining functions.

C The facility also can respond to major changes in mission or functional requirements. The assignment of other missions, such as an expanded technical control, requires that the facility have the capability to expand economically.

guidance 7 Security Operation


Exercise Room
Administration/Security
AB
Entry
Kitchen
Storage
OIC
NCIOC
Personnel Support
Recreation
Training/Library
D
Men
Laundry
Women
UPS/Battery
UPS/Power
Operations
Generator
Mechanical
Parts/Maint.
D
C

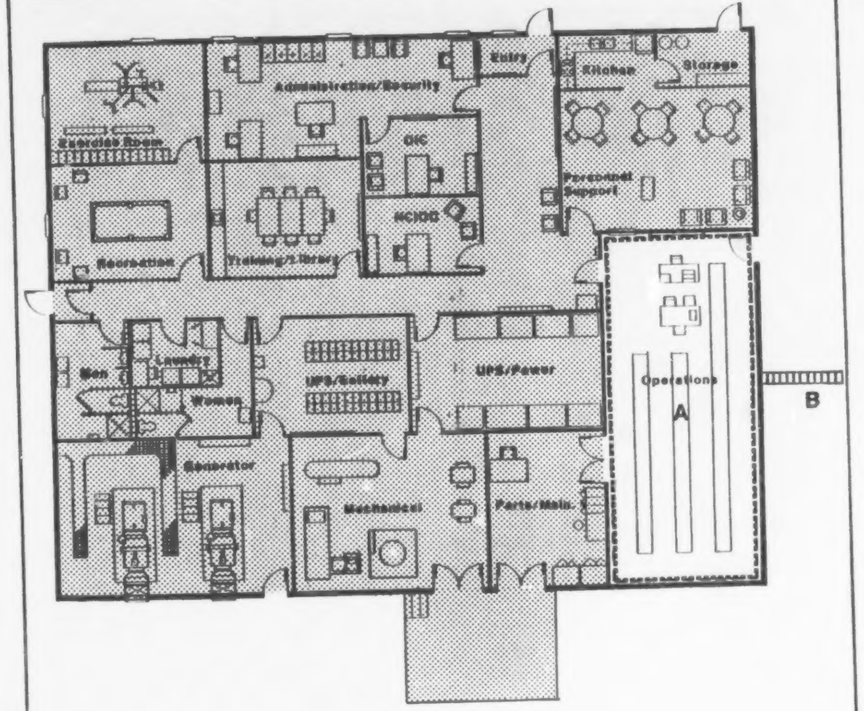
A The security workstation is located near a window to provide an overview for verification of entering visitors. In addition, this workstation is easily accessible to building occupants for efficient storage and distribution of all security documents.

B The security workstation will administer site security, monitor all intrusion detection systems, and initiate appropriate reactions to alert host-nation installation security teams. The security workstation is designed to provide an overview and control over site access and exterior fence gates.

C "Message" security is achieved by minimizing circulation in the cryptography equipment areas; i.e., the equipment is confined to the secure operations room.

D Required doors from other interior rooms (or from the outside) that open into secure rooms will have opening hardware only on the secure side.

guidance 8 Facility Security / Survivability


Exercise Room
Administration/Security
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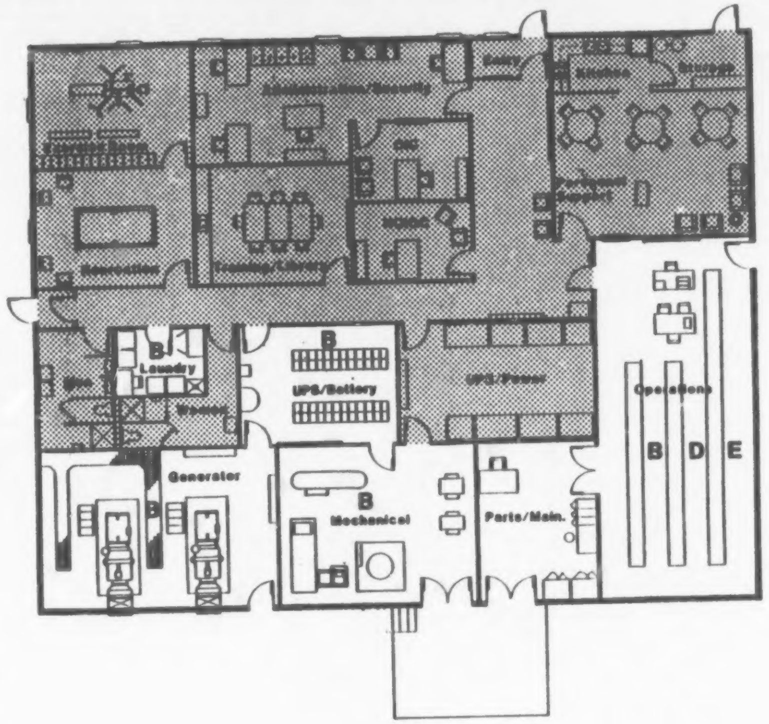
NCIOC
Personnel Support
Recreation
Training/Library
Men
Laundry
Women
UPS/Battery
UPS/Power
Operations
A
B
Generator
Mechanical
Parts/Maint.

A Conventional Class A vault construction is required for all spaces containing the communication system equipment--in this project, the DCS communication operations and technical control equipment. Efficient construction methods and future building expansion requirements are addressed by locating these functions close together. These spaces require vault-type construction to meet four requirements: (1) HEMP protection, (2) TEMPEST shielding, (3) building intrusion resistance, and (4) fire protection.

(See Volume 2, SB7, Security Systems, Section 5b--Guidance for building security construction of Zone 4.)

B DCS facilities require that waveguides be used to transport the communication signal between the antennas and the transmission/receiving equipment. Therefore, the transmission/receiving equipment is located at a minimal distance from the antennas and is protected physically to help ensure the facility's ability to perform it mission.

guidance 9 Fire Protection



Occupancy classifications: Business (NFPA); B-2 (UBC)

Hazard of contents classification: Ordinary hazard

Sprinkler protection classification: Ordinary hazard--group 2

Construction classifications/materials for fire protection (See Vol 2, SB3, Fire Protection/Life Safety)

Type II--Fire resistive (UBC) for security/armory spaces

CONSTRUCTION ELEMENT

Exterior walls	4-hr rated construction
Interior bearing walls	2-hr rated construction
Structural frame	2-hr rated construction
Permanent partitions	1-hr rated construction
Shaft enclosures	2-hr rated construction
Floors	2-hr rated construction
Roofs	2-hr rated construction

B Type II--one-hour (UBC) for battery, cryptography (Red and Black),* custodial, generator, operations,* mechanical, and technical control spaces

All construction elements....... 1-hr rated construction

Type II-N (UBC) for the other building spaces

All construction elements....... Noncombustible construction

Building separation

Site-specific information is required. Comply with Vol 2, SB3, Fire Protection/Life Safety.

Interior finishes

See Guidance/Life Safety.

Fire protection systems

Automatic fire suppression:

A water sprinkler system shall be provided throughout the facility.

Halon 1301 or carbon dioxide system shall be provided under all raised floor areas containing nonmetallic sheathed, exposed cables when the space under the raised floor is used as an air plenum.

Automatic notification/alarm:

General alarm activated by the automatic sprinkler system.

---

*See Vol 2, SB7, Security, for vault construction requirements that may be more stringent than those imposed by fire protection requirements.

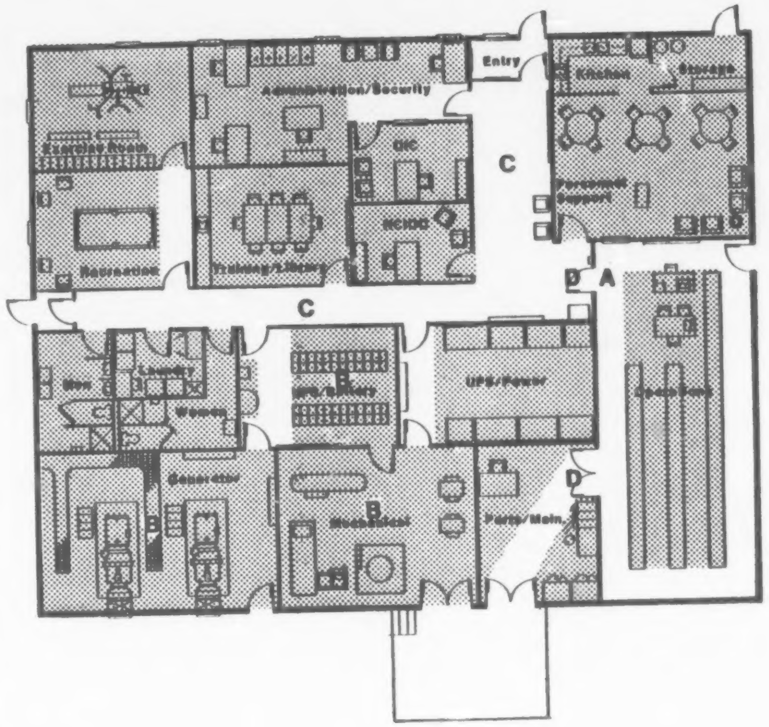
guidance 9

D Local alarm to sound in these spaces only, activated by smoke detectors.

Automatic fire detection

E Smoke detectors to activate local alarms in these spaces only. In rooms containing raised floor areas, smoke detectors shall be located under the raised floor.

guidance



Exit capacities

Corridors: 100 persons per unit of exit width for traveling either direction. The minimum width of any exit access corridor or passageway shall be 44 inches in the clear.
Doors: 100 persons per unit of exit width (a 3-foot door provides 1-1/2 units of exit width, providing exit capacity for 150 persons).

Number of exits

No less than two exits shall be accessible from every part of every floor. A single exit is permitted when the room or area has (1) a total occupant load of less than 100 persons, (2) direct exit to an open area outside the building at the ground level, and (3) a total travel distance on the same level of no more than 100 feet. (If stairs are involved, they shall be no more than 15 feet high and shall be provided with complete enclosures to separate them from all other building parts.

Exit travel distances

Required exits shall be located to allow access without passage through areas subject to locking. No dead-end corridor shall exceed 50 feet. The travel distance to exits shall be no more than 300 feet when the building is protected throughout by an approved automatic sprinkler system.

Arrangement of means of egress

Exit access and travel routes to exits are shown in the plan.

A Exit doors in vaulted areas containing communication system equipment are secured and permit exits only. Exit access routes through vaulted areas from spaces outside these areas are not permitted for security reasons.

B Two means of egress shall be provided from higher hazard areas, including mechanical and generator spaces. Exit access from any other space may not pass through mechanical or generator spaces (see exit marking). For security reasons, when mechanical or generator spaces have exit access routes through interior spaces, exit access doors from these spaces, when opened, shall sound an alarm and transmit a signal to the annunciator panel in the security space. Access for normal maintenance in mechanical and generator spaces shall be through the exterior doors.

Interior finishes

C Interior finishes in exit access corridors shall be Class A only.

Interior finishes in the remainder of the building shall be Class A or B only.

guidance 10

Illumination of means of egress

Exits and exit access, including stairs, aisles, corridors, and passageways leading to an exit, shall be illuminated continuously to values no less than 1 footcandle (measured at the floor) while the conditions of occupancy require that a means of egress be available.

Emergency lighting

Emergency lighting shall be provided in windowless buildings for designated aisles, corridors, and passageways leading to an exit. Emergency lighting shall maintain 1 footcandle of illumination throughout the means of egress for 1.5 hours in the event that normal lighting fails.

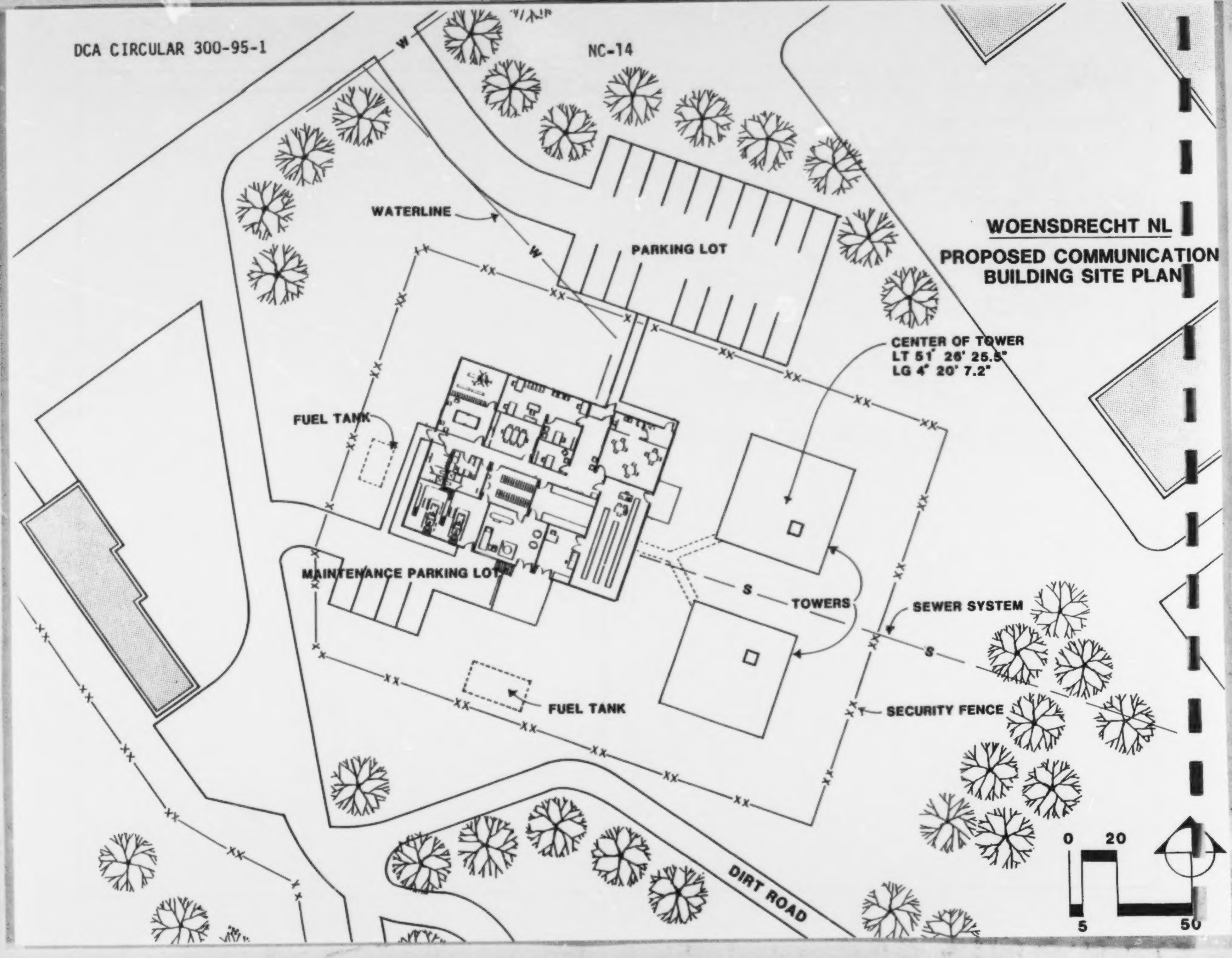
Marking of means of egress

Exits shall be marked by an approved sign readily visible from any direction of exit access. Sign placement shall be such that no point in the exit access is more than 100 feet from the nearest visible sign.

D Doors located or arranged so they are likely to be mistaken for exits shall be identified by a sign reading "NOT AN EXIT".

guidance

READEX FICHE



WOENSDRECHT NL

PROPOSED COMMUNICATION BUILDING SITE PLAN

WATERLINE
W
PARKING LOT
CENTER OF TOWER
LT 51° 26' 25.5"
LG 4° 20' 7.2"
FUEL TANK
MAINTENANCE PARKING LOT
S
TOWERS
SEWER SYSTEM
FUEL TANK
SECURITY FENCE
DIRT ROAD
0
20
5
50

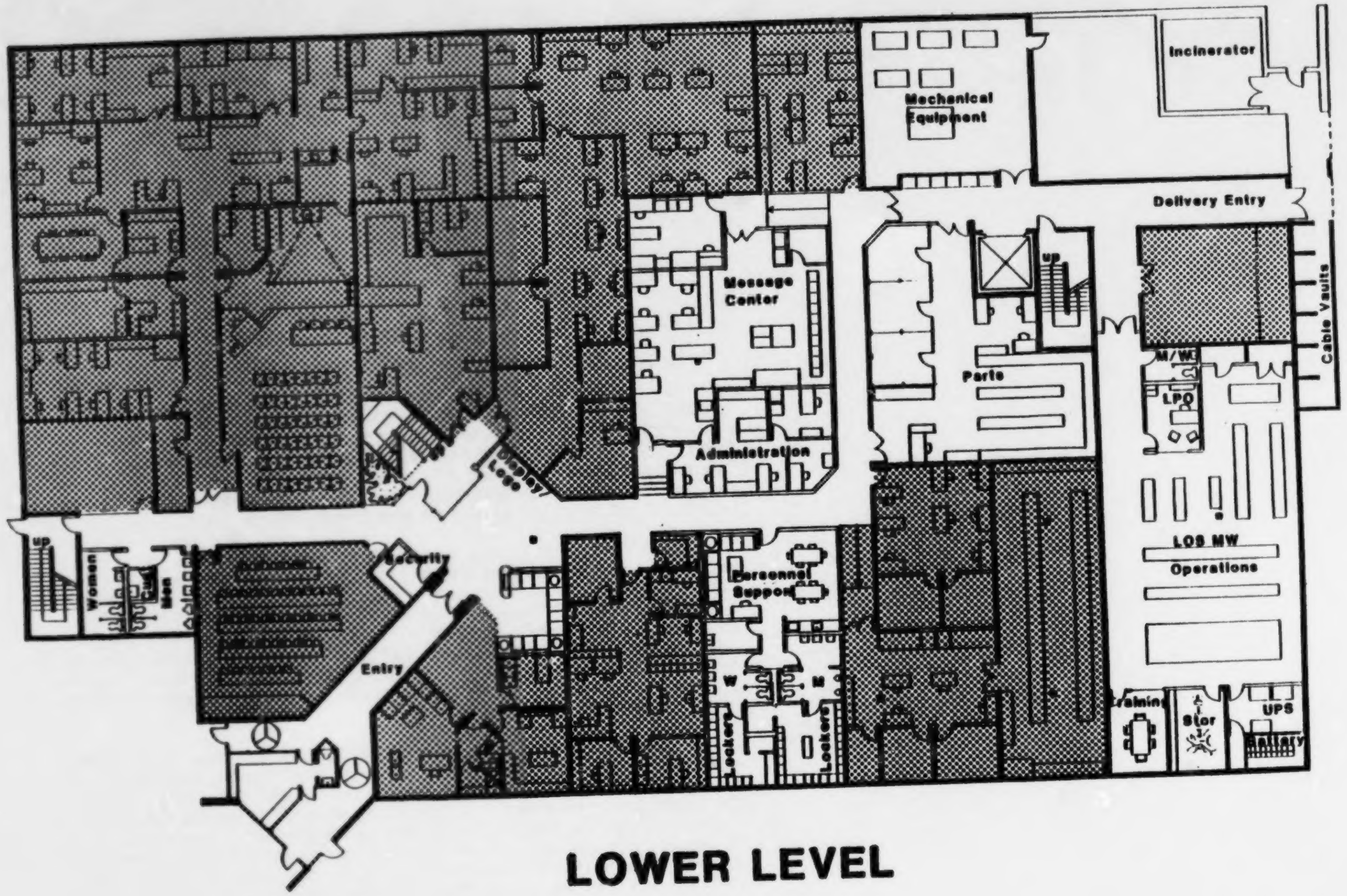
KAMISEYA, JAPAN

New Construction--C^3I Building and Site Development

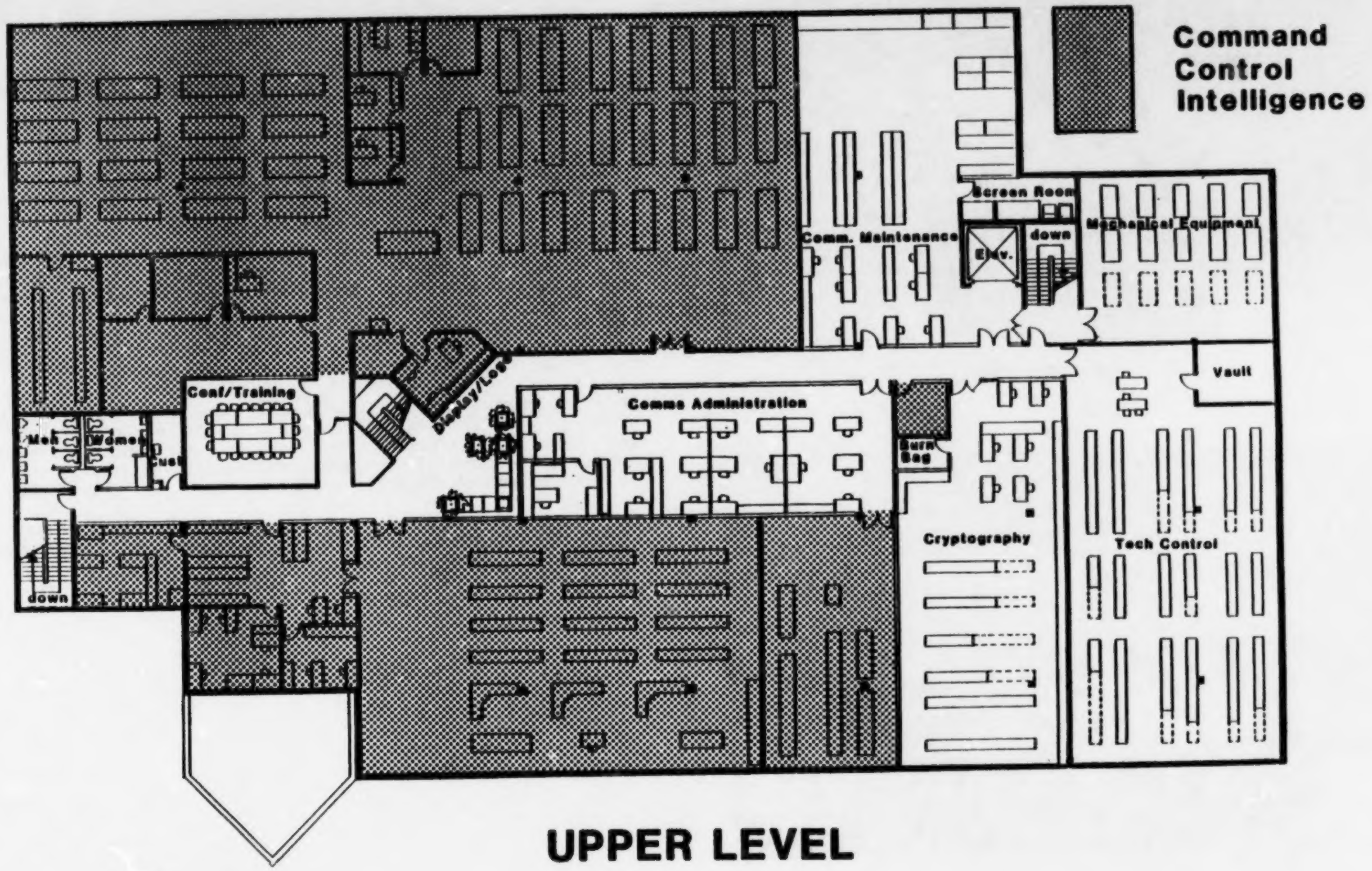
GIVEN: This project is a new construction communications, command, control, and intelligence (C^3I) facility for a major command-control center. It is to be approximately 75 percent command-control-related and 25 percent communication-related. The facility must consolidate several existing buildings that no longer can accommodate the extent of current technology in command-control equipment. Also, the dispersion of all C^3I activities among several buildings has been increasing personnel and upkeep costs.

OBJECTIVE: This new construction project will be programmed, designed, and constructed using the conventional Military Construction (MC) facility development process, which requires DD Form 1391 approval. All requirements should be generated for the 1391 based on an upgrade of the existing facilities now in use. For this project, each group using the future building should maintain security requirements consistent with existing policy; thus, the more security a group requires will determine where they will be located within the total building.

ACTION: The DCS communication operations section is shown with room names, whereas the command-control-intelligence facilities are shown shaded, without room names. In nearly all C^3I facilities, the DCS is included in similar multiuse buildings. This case study shows how the extent of DCS equipment can be determined at an early stage of the project so that the electronic equipment can be procured concurrent with building development. Also, there is a greater opportunity to have the equipment available on the date of beneficial occupancy of the total building if the electronic equipment is considered as much a part of the total DCS facility as are the other workstation furnishings. This DCS facility is designed with capability for line-of-site (LOS) microwave (MW) radio links and technical control (TC).

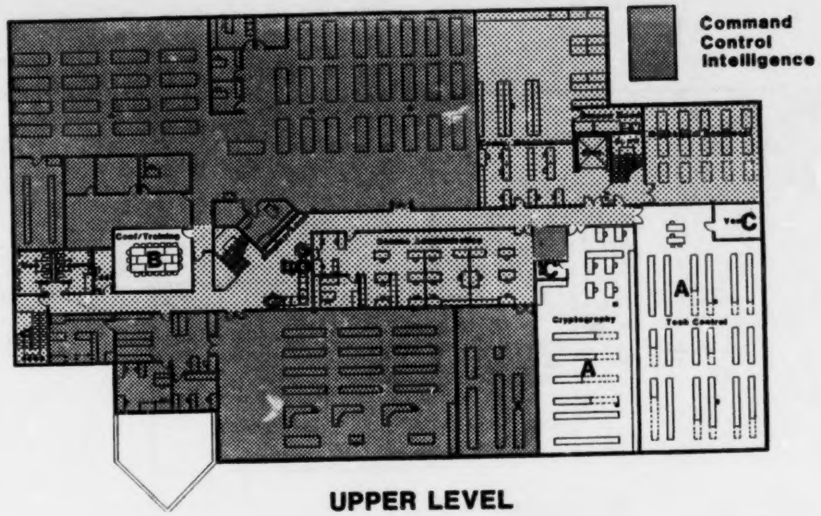

Incinerator
Mechanical Equipment
Delivery Entry
Message Center
Parts
up
Cable Vaults
M/W
LPO
Administration
Display
Logo
up
Women
Men
Security
Personnel Support
LOS MW
Operations
Entry
W
M
Lockers
Lockers
Training
Stor
UPS
Battery

LOWER LEVEL

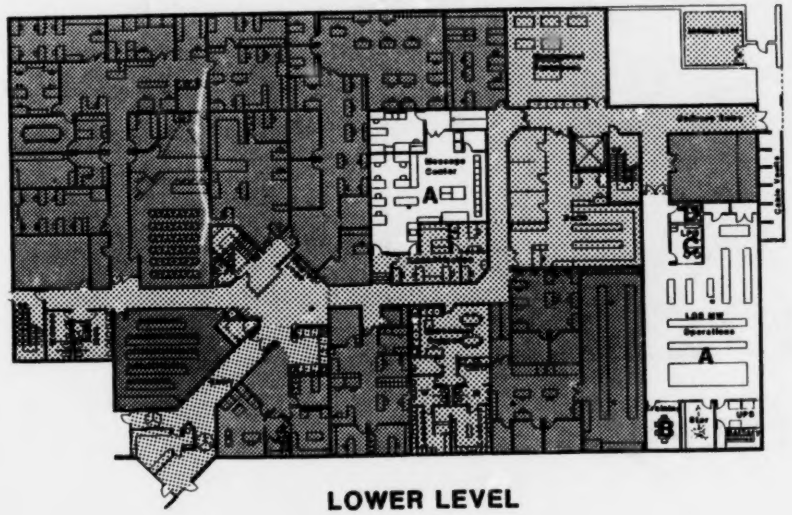

Command
Control
Intelligence
Screen Room
Comm. Maintenance
Elev.
down
Mechanical Equipment
Vault
Conf/Training
Display/Logs
Comms Administration
Men
Women
Cust
Burn Bag
Cryptography
Tech Control
down

UPPER LEVEL

guidance 1 Efficiency of Operational Functions



UPPER LEVEL



LOWER LEVEL

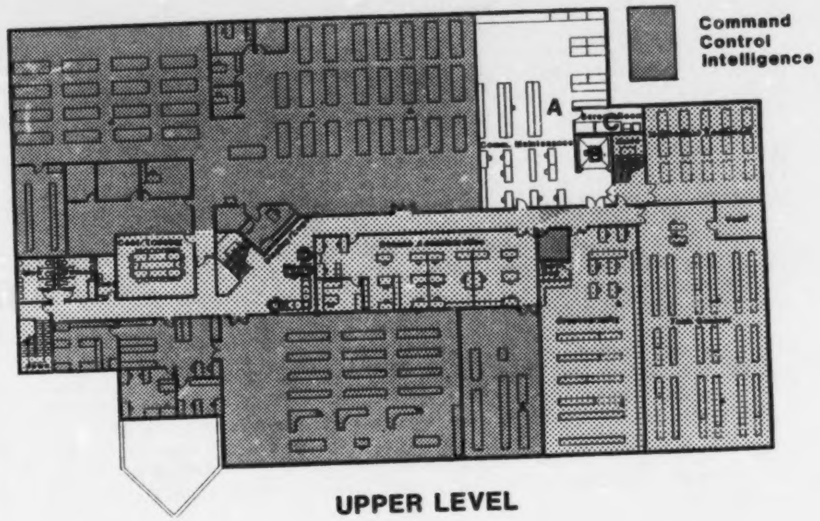
A Equipment is aligned in parallel rows in the operations modules for easy visual surveillance and direct access to all critical equipment. Multiple consoles in the TC area are adjacent to each other so that limited numbers of personnel can monitor them efficiently from one central location. Tables for audiovisual aids are available in the TC and LOS MW operations modules so that personnel can train on the job during regular watch periods.

B To improve the effectiveness of on-the-job training, small groups of four or five can be instructed in the training rooms on each floor. Some training involves both text reading and hands-on work with the communications equipment so that a close relationship is required between the training room and the TC operations module.

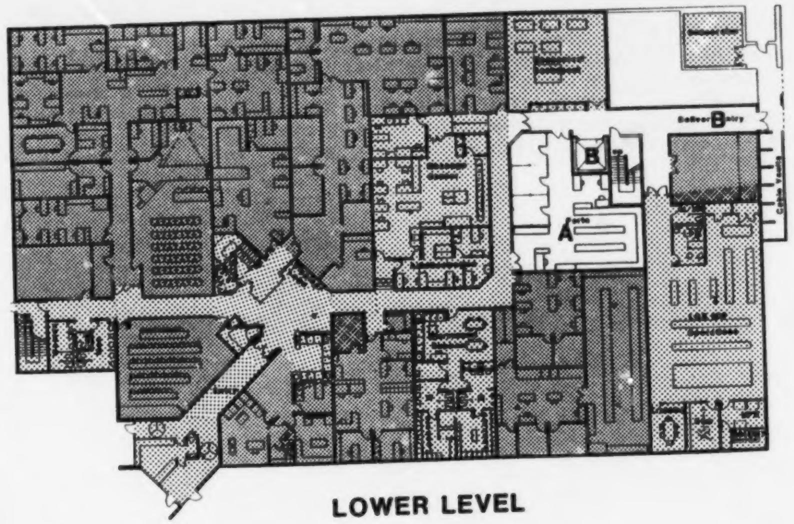
C Offices, vaults, and burn-bag rooms that have a close functional relationship to the operations activities are located adjacent to the various operations rooms.

D Personnel in the LOS MW operations module have easy access to toilet facilities.

guidance 2 Integration of Parts / Maint Modules with Ops



UPPER LEVEL



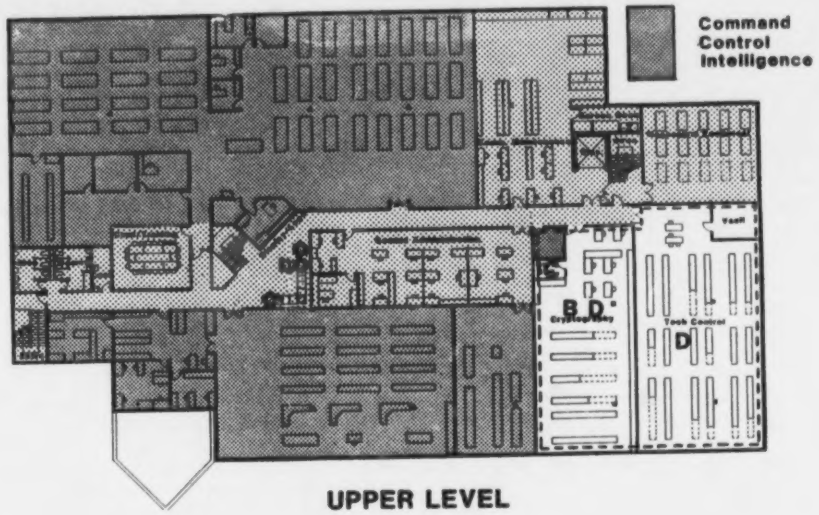
LOWER LEVEL

A Parts and maintenance rooms are well integrated and close to the operations spaces for optimal efficiency and minimal circulation.

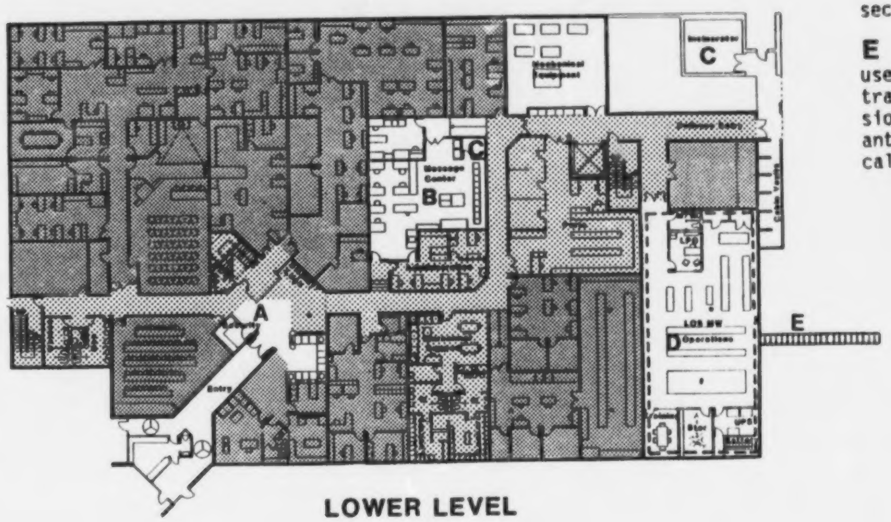
B Maintenance and parts rooms are located in the building such that all deliveries can be made directly and securely at one entry. Large communication equipment can be moved in and out more easily using the elevator located adjacent to the parts room on the lower level. Personnel can safely move large communication equipment vertically throughout the building via the elevator to the upper level that opens into the maintenance room.

C The screen room is isolated from radio frequency interference through its location and construction.

guidance 3 Security Operation



UPPER LEVEL



LOWER LEVEL

A The security guard is located with an overview to verify entering visitors. In addition, this space must be easily accessible to building occupants to help keep them aware of security problems.

B "Message" security is achieved by minimizing circulation between operations and the cryptography module; i.e., all classified equipment is confined to the upper-level controlled area.

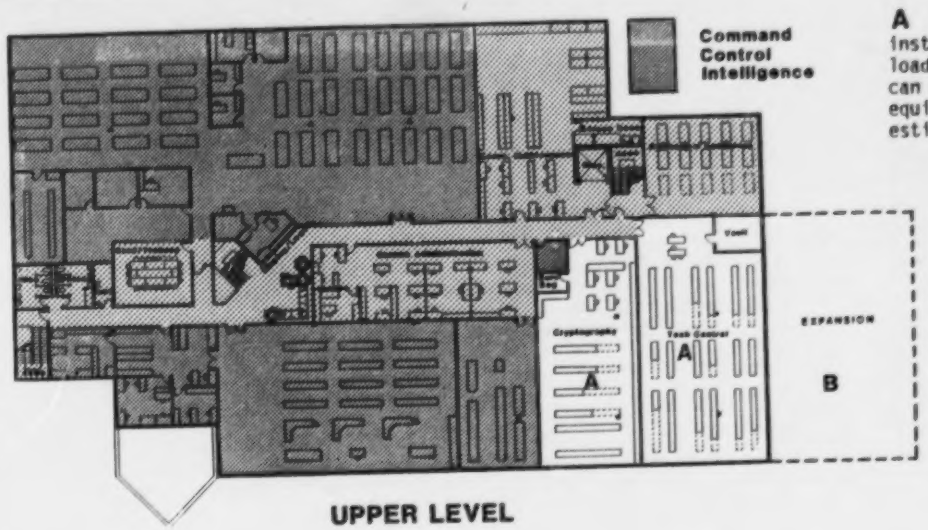
C Classified information on paper documents can be destroyed inside the controlled areas. Disposal equipment, which is controlled by appropriate personnel, is in the building on the upper level or at the incinerator space inside the station perimeter's secure area.

D Conventional Class A vault construction is required for all spaces containing the communication system equipment--LOS MW operations, cryptography, and technical control. Efficient construction methods and future building flexibility requirements are addressed by locating these spaces close together. These spaces require vault-type construction to meet four requirements: (1) HEMP protection, (2) TEMPEST shielding, (3) building intrusion resistance, and (4) fire protection.

(See SB7, Security Systems, Section 5b--Guidance for building security construction of Zone 4.)

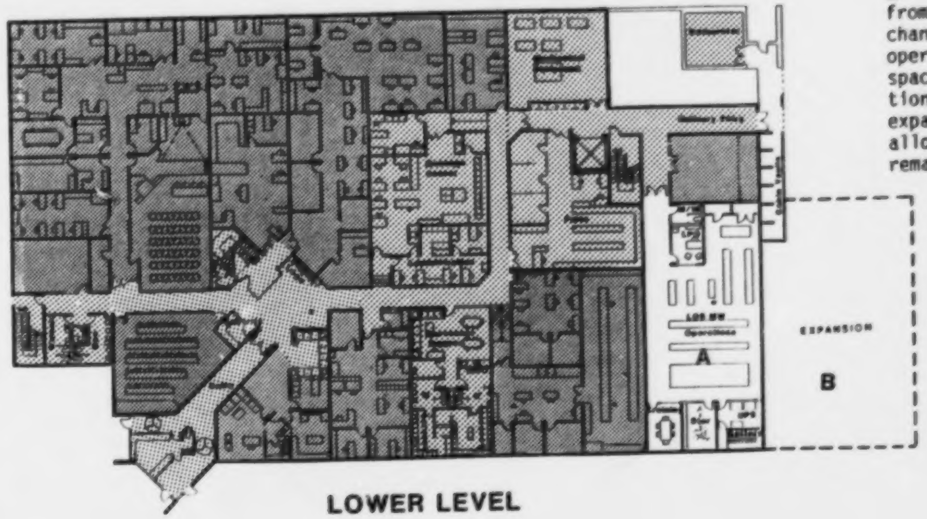
E The LOS MW communication equipment requires that waveguides be used in transporting the signal between the antenna towers and the transmission/receiving equipment. Therefore, the LOS MW transmission/receiving module is located at a minimal distance from the antenna tower. In addition, the waveguide will be protected physically to ensure the facility's capability of performing its mission.

guidance 4 Facility Expansion



UPPER LEVEL

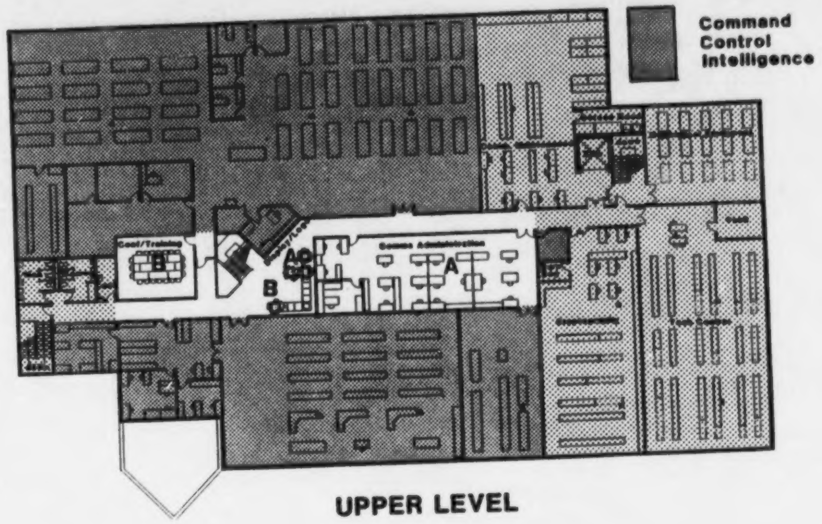
A The equipment layout has been planned to allow enough space to install the equipment needed to handle the maximum projected traffic load. The initial equipment layout is such that the station facility can be expanded without extensively rearranging already installed equipment. Space allowances for future equipment needs were estimated based on the requirements of similar installations.



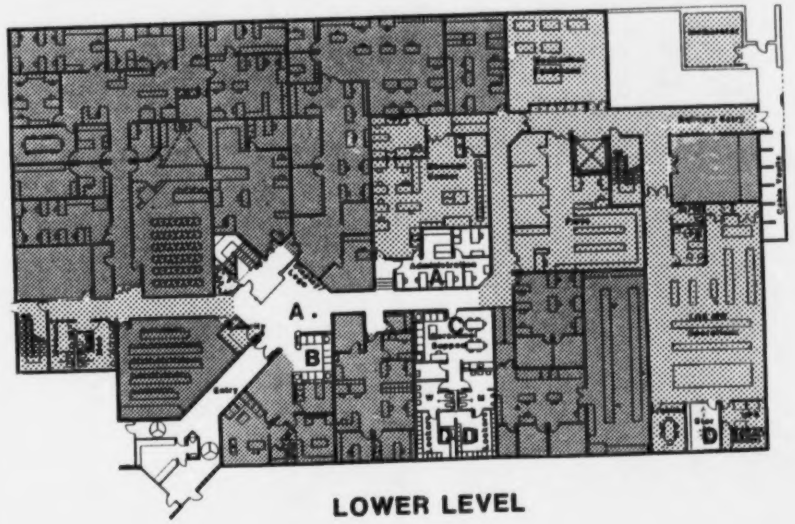
LOWER LEVEL

B The TC and LOS MW operations rooms are functionally isolated from the support and power modules. Due to the increasingly rapid changes in communications equipment technology, future demands on the operations rooms' spatial layout can be expected. Therefore, these spaces are designed to expand to accommodate new equipment and functions. The support and power spaces probably will not need this same expansion capability and therefore are located in defined areas to allow the operations spaces to expand without greatly affecting the remaining functions.

guidance 5 Efficiency and Accessibility of Admin Spaces



UPPER LEVEL



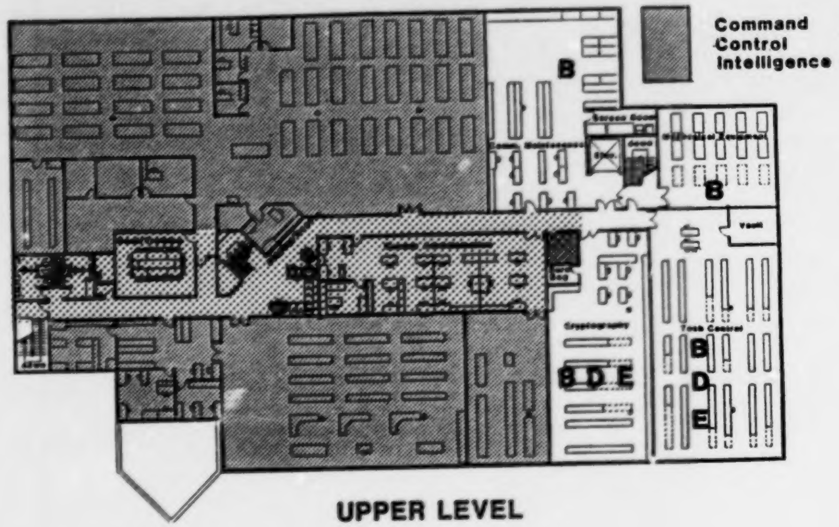
LOWER LEVEL

A Administration rooms are easily accessible to the public to minimize circulation and prevent visitor interference with facility operations. The administration spaces provide a buffer and transition zone between the exterior and secure interior spaces. The public corridors contain military unit logos and other display panels that relate to the "esprit de corps" and the C^3I facility's unit integrity.

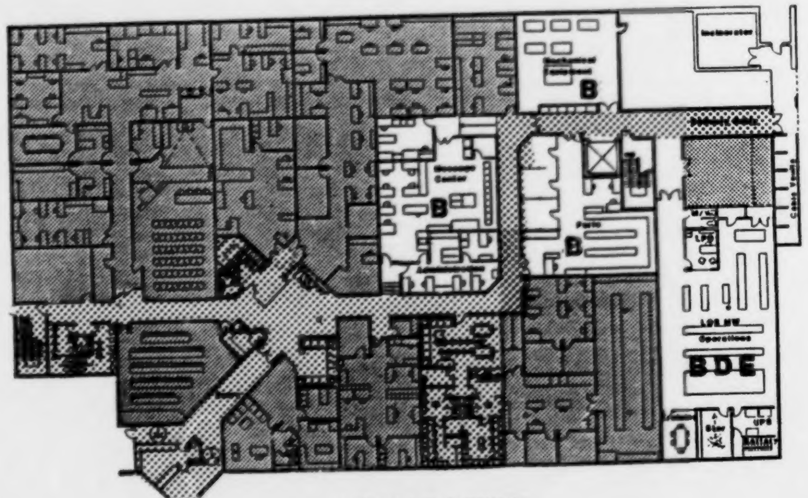
B The administration workstations' close relationship on the upper level will improve efficiency by minimizing public and administrative circulation and by producing group adjacency to shared conference and waiting areas.

C The intense activities at the communication station tend to generate personnel mental fatigue. It is therefore necessary to create a change of environment for on-duty personnel as a break from the hard-surface equipment rooms and work areas. The personnel support spaces are accessible from all operations rooms, but are isolated acoustically and visually.

D The provision of physical exercise equipment for personnel at DCS facilities is recommended. The necessary showers and lockers are adjacent to the personnel support room.



UPPER LEVEL



LOWER LEVEL

Occupancy classifications: Business (NFPA); B-2 (UBC)

Hazard of contents classification: Ordinary hazard

Sprinkler protection classification: Ordinary hazard--group 2

Construction classifications/materials for fire protection (See Vol 2, SB3, Fire Protection/Life Safety)

Type II--Fire resistive (UBC) for security/armory spaces

CONSTRUCTION ELEMENT	
Exterior walls	4-hr rated construction
Interior bearing walls	2-hr rated construction
Structural frame	2-hr rated construction
Permanent partitions	1-hr rated construction
Shaft enclosures	2-hr rated construction
Floors	2-hr rated construction
Roofs	2-hr rated construction

B Type II--one-hour (UBC) for battery, cryptography (Red and Black),* custodial, generator, operations,* mechanical, and technical control spaces

All construction elements....... 1-hr rated construction

Type II-N (UBC) for the other building spaces

All construction elements....... Noncombustible construction

Building separation

Site-specific information is required. Comply with Vol 2, SB3. Fire Protection/Life Safety.

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*See Vol 2, SB7, Security, for vault construction requirements that may be more stringent than those imposed by fire protection requirements.

guidance 6 Fire Protection

Interior finishes

See Guidance/Life Safety.

Fire protection systems

Automatic fire suppression:

A water sprinkler system shall be provided throughout the facility.

Halon 1301 or carbon dioxide system shall be provided under raised floor areas containing nonmetallic sheathed, exposed cables when the space under the raised floor is used as an air plenum.

Automatic notification/alarm:

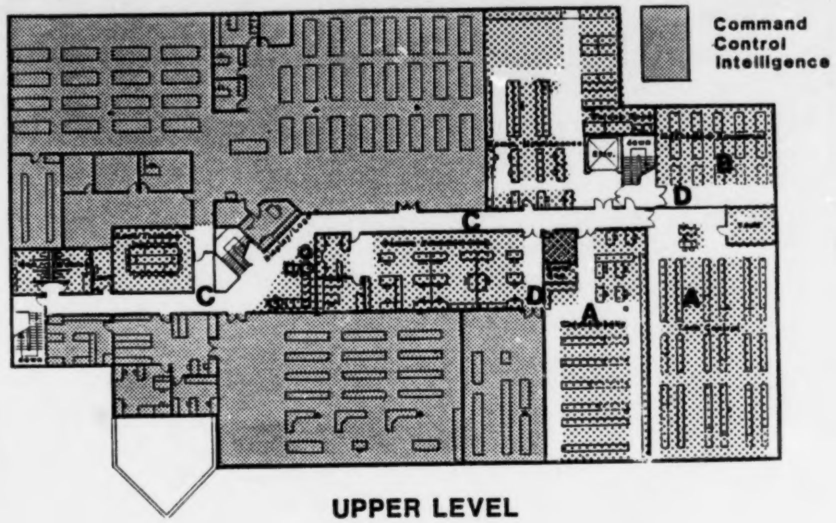
General alarm activated by the automatic sprinkler system.

D Local alarm to sound in these spaces only, activated by smoke detectors.

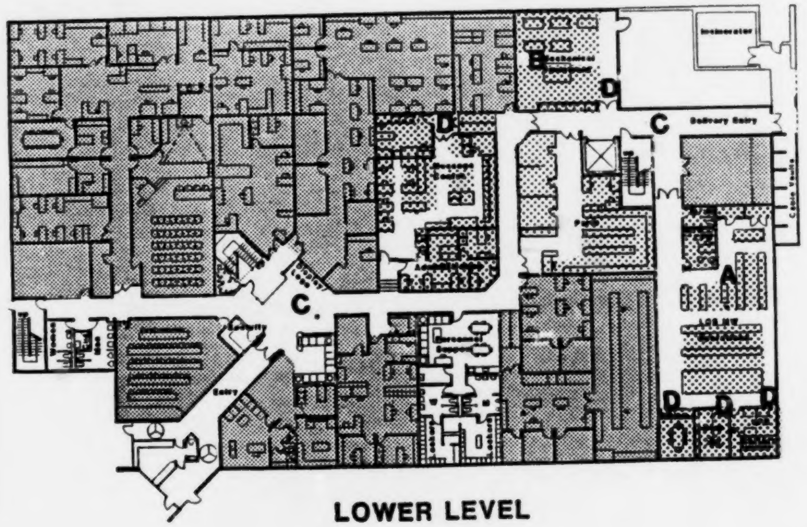
Automatic fire detection

E Smoke detectors to activate local alarms in these spaces only. In rooms containing raised floor areas, smoke detectors shall be located under the raised floor.

guidance



UPPER LEVEL



LOWER LEVEL

Exit capacities

Corridors: 100 persons per unit of exit width for traveling either direction. The minimum width of any exit access corridor or passageway shall be 44 inches in the clear.
Doors: 100 persons per unit of exit width (a 3-foot door provides 1-1/2 units of exit width, providing exit capacity for 150 persons).

Number of exits

No less than two exits shall be accessible from every part of every floor. A single exit is permitted when the room or area has (1) a total occupant load of less than 100 persons, (2) direct exit to an open area outside the building at the ground level, and (3) a total travel distance on the same level of no more than 100 feet. (If stairs are involved, they shall be no more than 15 feet high and shall be provided with complete enclosures to separate them from all other building parts.

Exit travel distances

Required exits shall be located to allow access without passage through areas subject to locking. No dead-end corridor shall exceed 50 feet. The travel distance to exits shall be no more than 300 feet when the building is protected throughout by an approved automatic sprinkler system.

Arrangement of means of egress

Exit access and travel routes to exits are shown in the plan.
A Exit doors in vaulted areas containing communication system equipment are secured and permit exits only. Exit access routes through vaulted areas from spaces outside these areas are not permitted for security reasons.

B Two means of egress shall be provided from higher hazard areas, including mechanical and generator spaces. Exit access from any other space may not pass through mechanical or generator spaces (see exit marking). For security reasons, when mechanical or generator spaces have exit access routes through interior spaces, exit access doors from these spaces, when opened, shall sound an alarm and transmit a signal to the annunciator panel in the security space. Access for normal maintenance in mechanical and generator spaces shall be through the exterior doors.

Interior finishes

C Interior finishes in exit access corridors shall be Class A only.

Interior finishes in the remainder of the building shall be Class A or B only.

guidance 7 Life Safety

Illumination of means of egress

Exits and exit access, including stairs, aisles, corridors, and passageways leading to an exit, shall be illuminated continuously to values no less than 1 footcandle (measured at the floor) while the conditions of occupancy require that a means of egress be available.

Emergency lighting

Emergency lighting shall be provided in windowless buildings for designated aisles, corridors, and passageways leading to an exit. Emergency lighting shall maintain 1 footcandle of illumination throughout the means of egress for 1.5 hours in the event that normal lighting fails.

Marking of means of egress

Exits shall be marked by an approved sign readily visible from any direction of exit access. Sign placement shall be such that no point in the exit access is more than 100 feet from the nearest visible sign.

D Doors located or arranged so they are likely to be mistaken for exits shall be identified by a sign reading "NOT AN EXIT".

guidance

CAMP CARROLL, KOREA

New Construction--DCS Bunker Building

GIVEN: This project is for new construction in the development of the DCS fiber optics improvement program at an existing military post outside the continental United States (OCONUS). The building will be located underground as a bunker to meet the station survivability requirements. The complete power backup system and all DCS communication equipment will be included in the bunker. Host-nation military installation personnel will provide the necessary security and survivability activities and any required defensive action against hostile threats.

OBJECTIVE: The objective is to construct the facility as a prototype for many sites that will be replicated as DCS survivability requirements warrant. The project will be built using the Military Construction (MC) cycle. Each site should include a main communication operations space and the required backup power spaces.

ACTION: The decision to use a rock overburden blast shield will greatly reduce the building's structural strength requirements. Thus, the building perimeter walls and roof structure can be "thinner" than if the blast shield were not used. It should be noted on both drawings--the longitudinal section and the cross section--that conventional equipment considerations (such as a raised floor for accessibility to equipment and an attic space above the ceiling) are similar to other DCS communication facility projects. It is especially appropriate for this facility to be built as a bunker since the fiber optics communication system does not require the normally vulnerable antenna towers used in all other DCS transmission modes. The bunker is sized to accommodate the thicker perimeter walls and other structural components so that when the project is approved on the DD Form 1391, the entire functional area is documented in addition to the important requirement for gross square feet occupied by the structural walls.

Case Study
TPICK, Korea

Army

EXISTING FACILITIES/DEFICIENCY DETAIL DATA

Scope of FY85 Request: 2900 square feet

Requirement Computations

MISSION: The DCS Korea TPICK program mission is to provide a survivable primary communication system for U.S. Forces in Korea.

REQUIREMENT: A 2900 square foot bunker is required to house communication equipment and emergency generators.

Requirements/Assets

		Scope (sq ft)	No. of Bldgs.
a.	Total requirement	2900	1
b.	Existing substandard	0	
c.	Existing adequate	0	
d.	Funded, not in inventory	0	
e.	Adequate assets (c+d)	0	
f.	Unfunded prior authorization	0	
g.	Included in prior FY programs	0	
h.	Deficiency (a-e-f-g)	2900	1

MILITARY CONSTRUCTION PROJECT DATA (as required on DD Form 1391)

Description of proposed construction: construct a new reinforced concrete bunker building to house the TPICK communications equipment. Include the following necessary support facilities: electric, water, sanitary sewer, site improvement, fencing, pavements, underground fuel storage, hookups, and additional materials for Government-furnished engine-generators. The TPICK communications building will include technical, mechanical, administrative, and electrical areas. Air-conditioning should support 10 tons.

requirements

Requirement

Provide 2900 square feet.

Project

This project will provide a permanent bunker facility to accommodate the TPICK fiber optic and microwave radio communication equipment for the DCS in Korea. This site is part of a total upgrade of DCS facilities.

Requirement

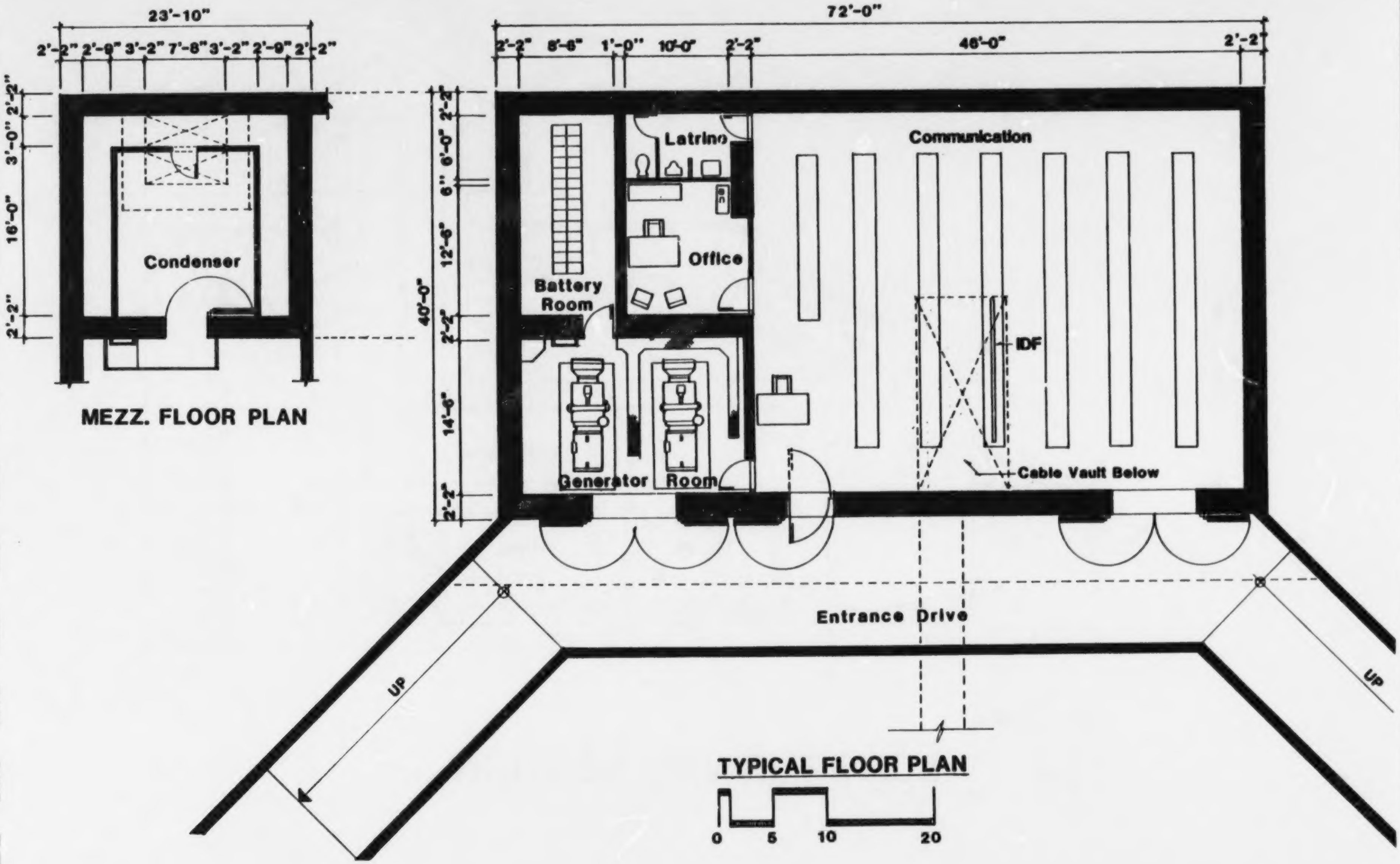
TPICK is a communication system improvement program to improve DCS survivability in Korea. This series of projects includes survivability improvements in both the transmission mode, as fiber optic links, and the communication facilities, as reinforced concrete bunkers. The system handles communication traffic in both voice and data modes. It serves all U.S. forces in Korea either directly or indirectly.

Current Situation

The current DCS facilities are not constructed to withstand direct impact of conventional bomb attacks. This upgrade will increase survivability potential for the DCS in Korea.

Impact If Not Provided

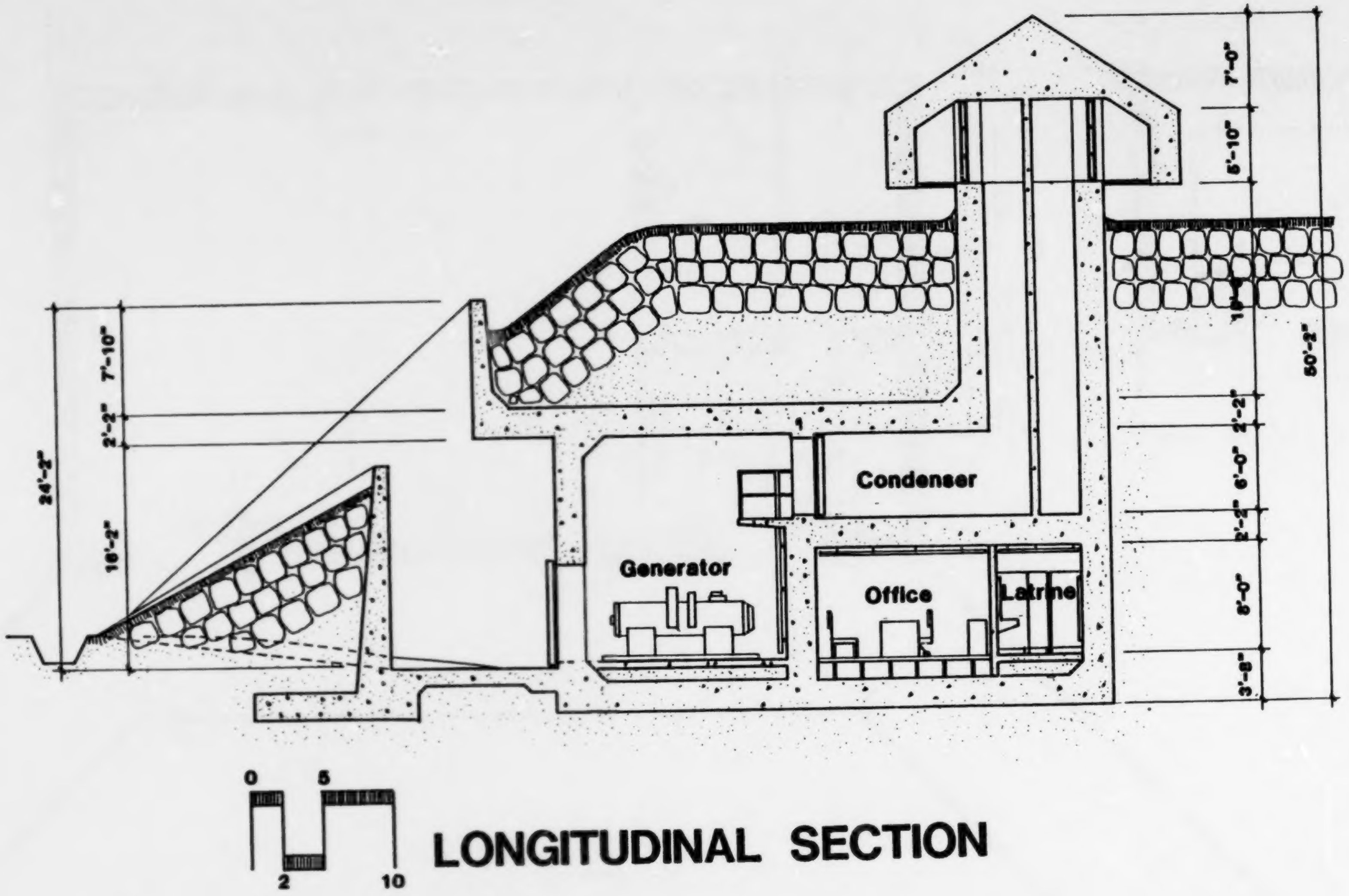
Without this site improvement, the total TPICK plan would not obtain the level of survivability considered vital to maintaining the DCS in Korea.


23'-10"
2'-2"
2'-9"
3'-2"
7'-8"
3'-2"
2'-9"
2'-2"
2'-2"
3'-0"
16'-0"
2'-2"
Condenser

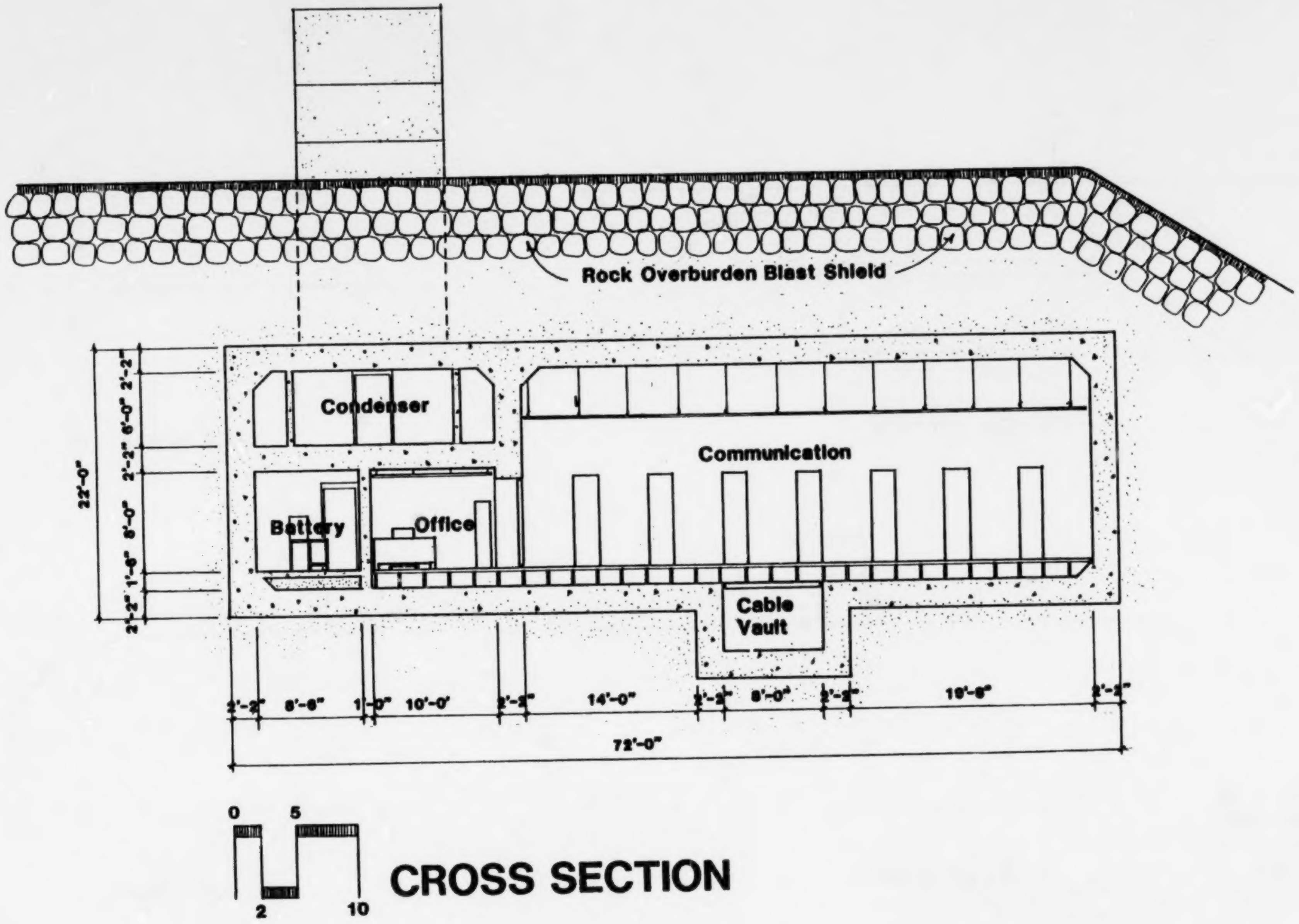
MEZZ. FLOOR PLAN

72'-0"
2'-2"
8'-6"
1'-0"
10'-0"
2'-2"
46'-0"
2'-2"
40'-0"
2'-2"
6'-0"
6"
12'-6"
2'-2"
14'-6"
2'-2"
Latrine
Office
Battery Room
Generator Room
Communication
IDF
Cable Vault Below
Entrance Drive
UP
UP
0
5
10
20

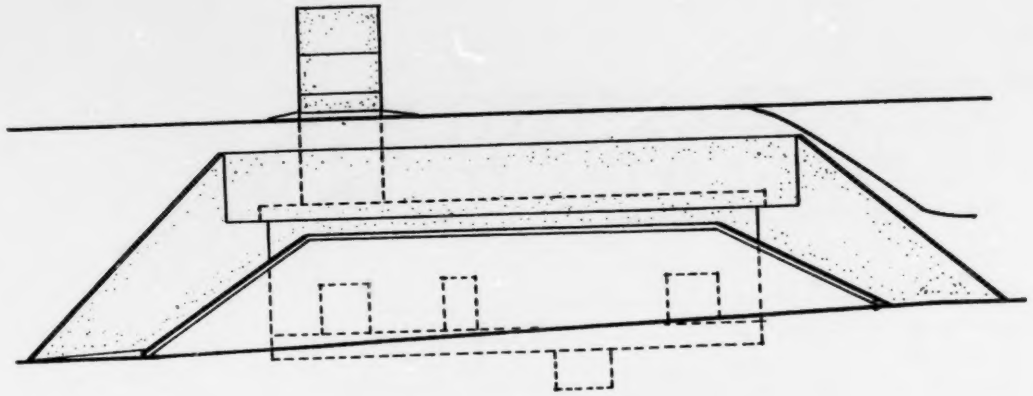
TYPICAL FLOOR PLAN


7'-0"
5'-10"
50'-2"
2'-2"
6'-0"
2'-2"
8'-0"
3'-8"
24'-2"
7'-10"
2'-2"
16'-2"
Condenser
Generator
Office
Latrine
0
5
2
10

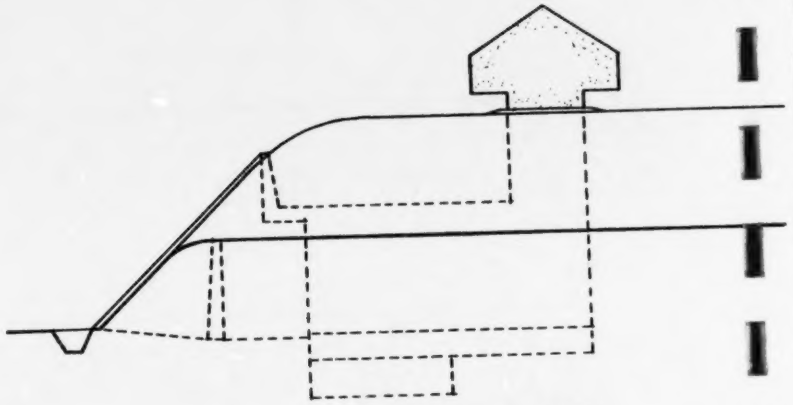
LONGITUDINAL SECTION


Rock Overburden Blast Shield
Condenser
Communication
Battery
Office
Cable Vault
22'-0"
2'-2"
6'-0"
2'-2"
8'-0"
1'-6"
2'-2"
2'-2"
8'-6"
1'-0"
10'-0'
2'-2"
14'-0"
2'-2"
8'-0"
2'-2"
19'-6"
2'-2"
72'-0"
0
5
2
10

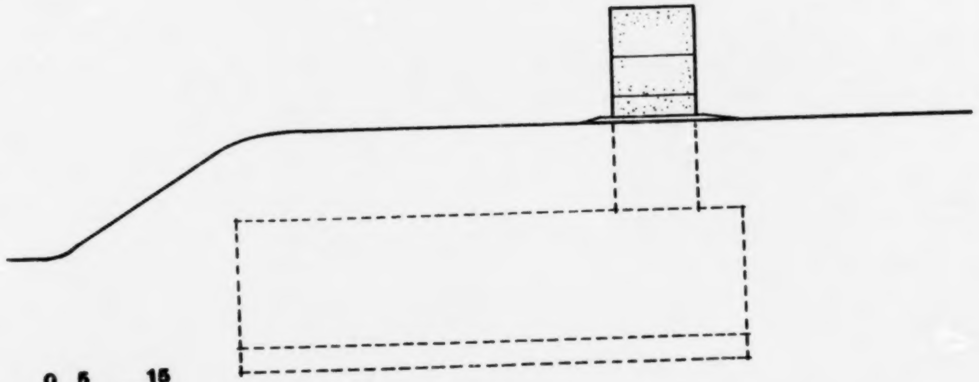
CROSS SECTION



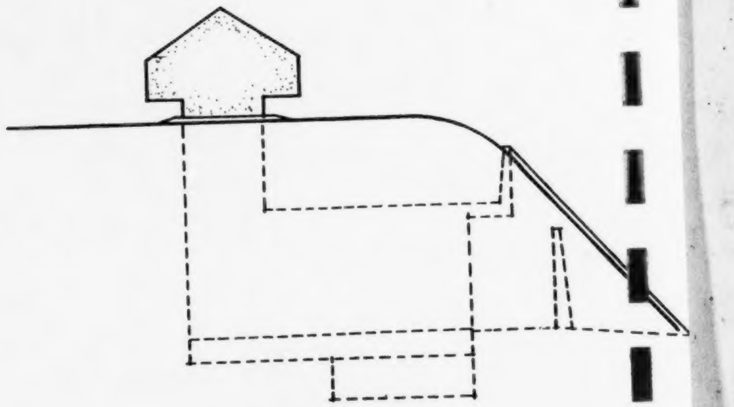
FRONT ELEVATION



SIDE ELEVATION

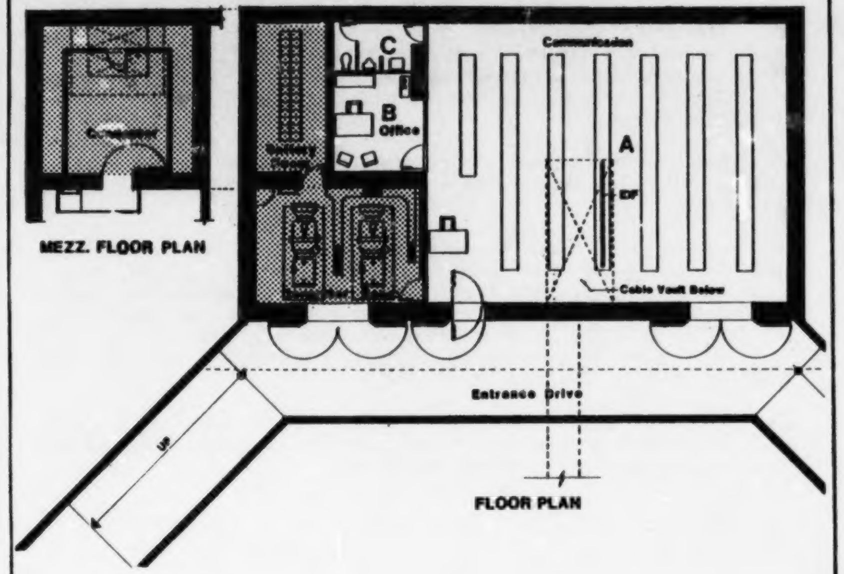


REAR ELEVATION



SIDE ELEVATION

guidance 1 Efficiency of Operational Functions

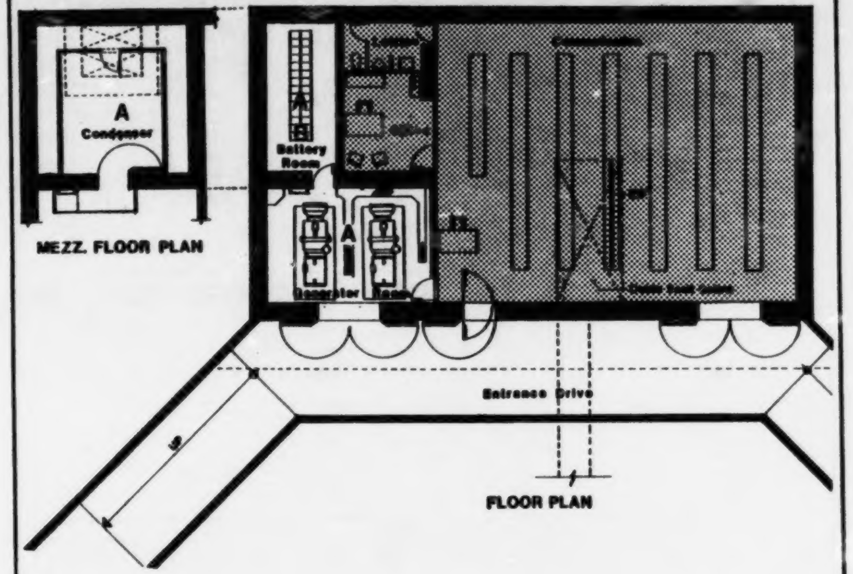

MEZZ. FLOOR PLAN
C
B
Office
Communication
A
DF
Cable Vault Below
Entrance Drive
UP
FLOOR PLAN

A Equipment is aligned in parallel rows in the communication operations space for easy visual surveillance and direct access to all critical equipment. Tables for audiovisual aids are available so that personnel can train on the job during regular watch periods.

B The administration spaces are easily accessible to authorized visitors. This will minimize circulation and prevent visitor interference with facility operations.

C Personnel in the communication space have easy access to toilet facilities.

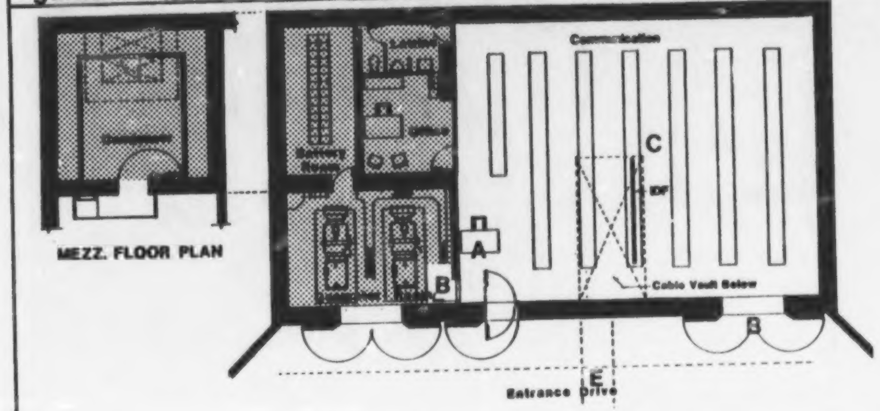
guidance 2 Integration Of Power / UPS Modules

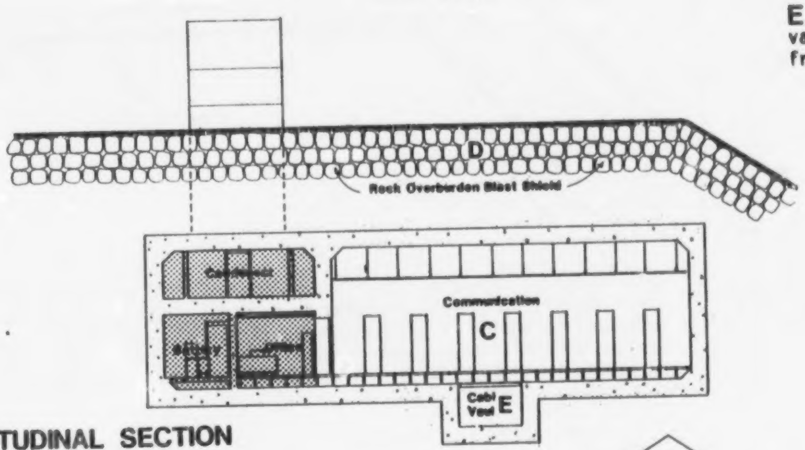

A
Condenser
MEZZ. FLOOR PLAN
A
B
Battery Room
A
Generator Room
Entrance Drive
UP
FLOOR PLAN

A Spaces that comprise the power and UPS equipment areas are close together and well integrated. Direct physical adjacencies provide economy by minimizing cable lengths and produce personnel efficiency through interaccess relationships. Separating the power equipment on structural isolation pads minimizes the impact of generator vibrations on the communications equipment.

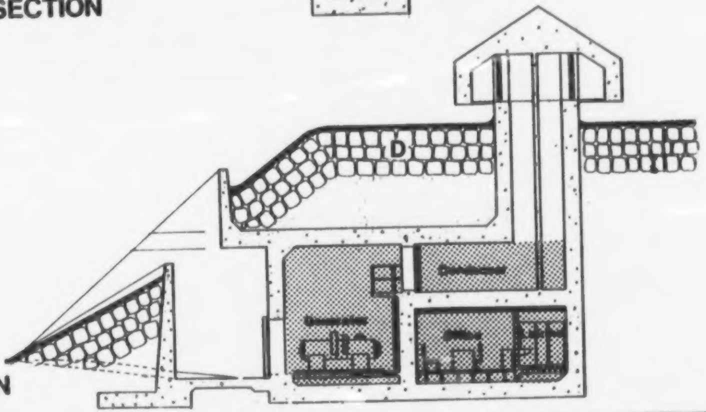
B Direct exterior ventilation of the battery room is more energy efficient when makeup air is conditioned by being ducted through the generator room. The battery room ventilation supply air is heated upon passing through the generator room and is then exhausted up through the condenser room.

guidance 3 Security / Survivability


Communication
C
IDF
A
B
B
Cable Vault Below
E
Entrance Drive
MEZZ. FLOOR PLAN


D
Rock Overburden Blast Shield
Communication
C
Cable Vault
E

LONGITUDINAL SECTION



CROSS SECTION

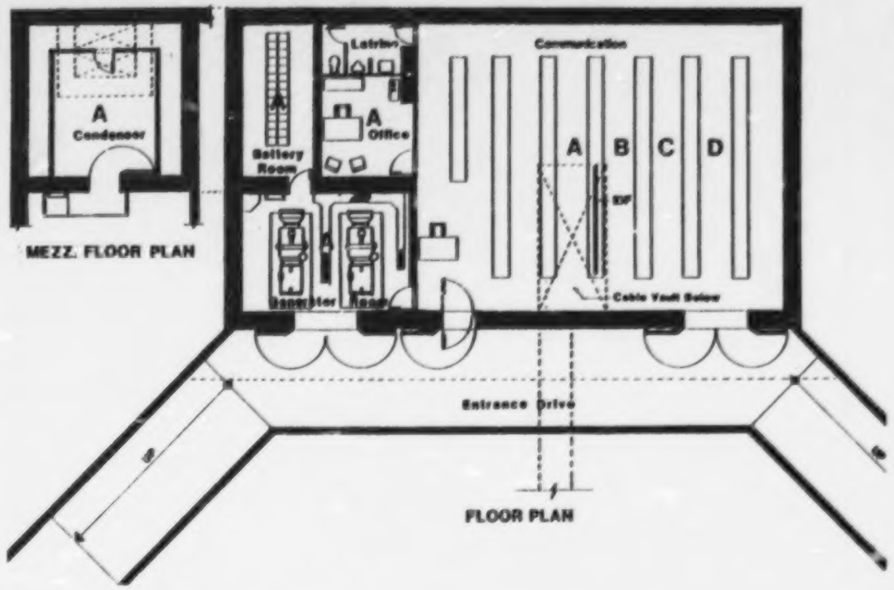
A The shift supervisor's desk is located with an overview to verify entering visitors. This workstation also is located here to allow communication personnel to administer site security, monitor all intrusion detection systems, and initiate appropriate reactions to hostile threats.

B Required doors from the generator room and from the outside that open into the secure area will have opening hardware only on the secure side.

C Conventional Class A vault construction is required for the space containing the communication system equipment, including fiber-optic and technical control equipment. This space requires vault-type construction to meet four requirements: (1) HEMP protection, (2) TEMPEST shielding, (3) building survivability, and (4) fire protection. (See SB7, Security Systems, Section 5b--Guidance for building security construction of Zone 4.)

E This DCS bunker facility requires that a below-grade cable vault be used to protect the fiber-optic communication lines to and from the transmission/receiving equipment.

guidance 4 Fire Protection



MEZZ. FLOOR PLAN

FLOOR PLAN

Occupancy classifications: Business (NFPA); B-2 (UBC)

Hazard of contents classification: Ordinary hazard

Sprinkler protection classification: Ordinary hazard--group 2

Construction classifications/materials for fire protection (See Vol 2, SB3, Fire Protection/Life Safety)

A Type II--Fire resistive (UBC) for security/armory spaces

NONE

CONSTRUCTION ELEMENT	
Exterior walls....................	4-hr rated construction
Interior bearing walls............	2-hr rated construction
Structural frame..................	2-hr rated construction
Permanent partitions..............	1-hr rated construction
Shaft enclosures..................	2-hr rated construction
Floors............................	2-hr rated construction
Roofs.............................	2-hr rated construction

B Type II--one-hour (UBC) for battery, cryptography (Red and Black),* custodial, generator, operations,* mechanical, and technical control spaces

All construction elements....... 1-hr rated construction

Type II-N (UBC) for the other building spaces

All construction elements....... Noncombustible construction

Building separation

Site-specific information is required. Comply with Vol 2, SB3, Fire Protection/Life Safety.

Interior finishes

See Guidance/Life Safety.

Fire protection systems

Automatic fire suppression:

A water sprinkler system shall be provided throughout the facility.

Halon 1301 or carbon dioxide system shall be provided under all raised floor areas containing nonmetallic sheathed, exposed cables when the space under the raised floor is used as an air plenum.

Automatic notification/alarm:

General alarm activated by the automatic sprinkler system.

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*See Vol 2, SB7, Security, for vault construction requirements that may be more stringent than those imposed by fire protection requirements.

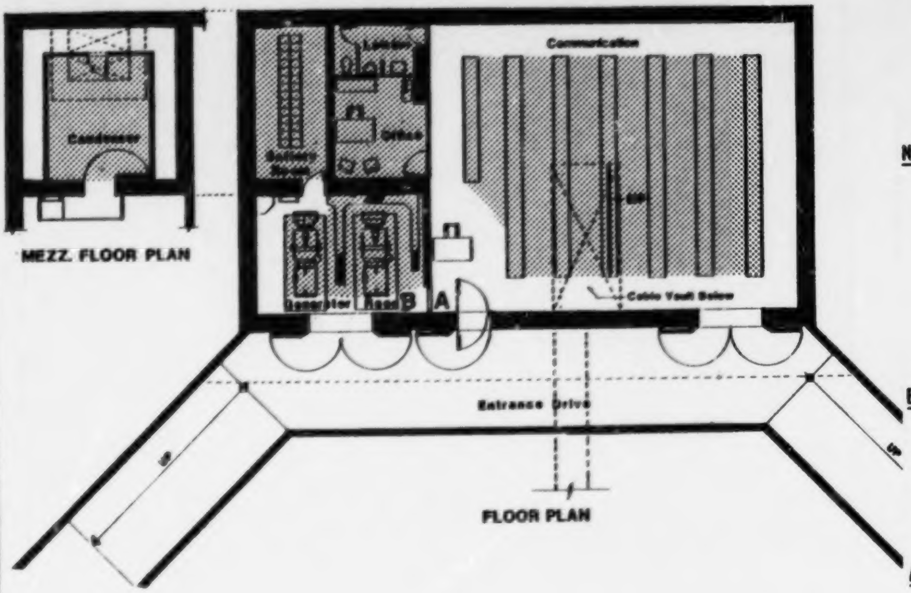
guidance 4

C Local alarm to sound in these spaces only, activated by smoke detectors.

Automatic fire detection

D Smoke detectors to activate local alarms in these spaces only. In rooms containing raised floor areas, smoke detectors shall be located under the raised floor.

guidance



Exit capacities

Corridors: 100 persons per unit of exit width for traveling either direction. The minimum width of any exit access corridor or passageway shall be 44 inches in the clear.
Doors: 100 persons per unit of exit width (a 3-foot door provides 1-1/2 units of exit width, providing exit capacity for 150 persons).

Number of exits

No less than two exits shall be accessible from every part of every floor. A single exit is permitted when the room or area has (1) a total occupant load of less than 100 persons, (2) direct exit to an open area outside the building at the ground level, and (3) a total travel distance on the same level of no more than 100 feet. (If stairs are involved, they shall be no more than 15 feet high and shall be provided with complete enclosures to separate them from all other building parts.

Exit travel distances

Required exits shall be located to allow access without passage through areas subject to locking. No dead-end corridor shall exceed 50 feet. The travel distance to exits shall be no more than 300 feet when the building is protected throughout by an approved automatic sprinkler system.

Arrangement of means of egress

Exit access and travel routes to exits are shown in the plan.
A Exit doors in vaulted areas containing communication system equipment are secured and permit exits only. Exit access routes through vaulted areas from spaces outside these areas are not permitted for security reasons.

Two means of egress shall be provided from higher hazard areas, including mechanical and generator spaces. Exit access from any other space may not pass through mechanical or generator spaces (see exit marking). For security reasons, when mechanical or generator spaces have exit access routes through interior spaces, exit access doors from these spaces, when opened, shall sound an alarm and transmit a signal to the annunciator panel in the security space. Access for normal maintenance in mechanical and generator spaces shall be through the exterior doors.

Interior finishes

Interior finishes in exit access corridors shall be Class A only.

Interior finishes in the remainder of the building shall be Class A or B only.

guidance 5

Illumination of means of egress

Exits and exit access, including stairs, aisles, corridors, and passageways leading to an exit, shall be illuminated continuously to values no less than 1 footcandle (measured at the floor) while the conditions of occupancy require that a means of egress be available.

Emergency lighting

Emergency lighting shall be provided in windowless buildings for designated aisles, corridors, and passageways leading to an exit. Emergency lighting shall maintain 1 footcandle of illumination throughout the means of egress for 1.5 hours in the event that normal lighting fails.

Marking of means of egress

Exits shall be marked by an approved sign readily visible from any direction of exit access. Sign placement shall be such that no point in the exit access is more than 100 feet from the nearest visible sign.

B Doors located or arranged so they are likely to be mistaken for exits shall be identified by a sign reading "NOT AN EXIT".

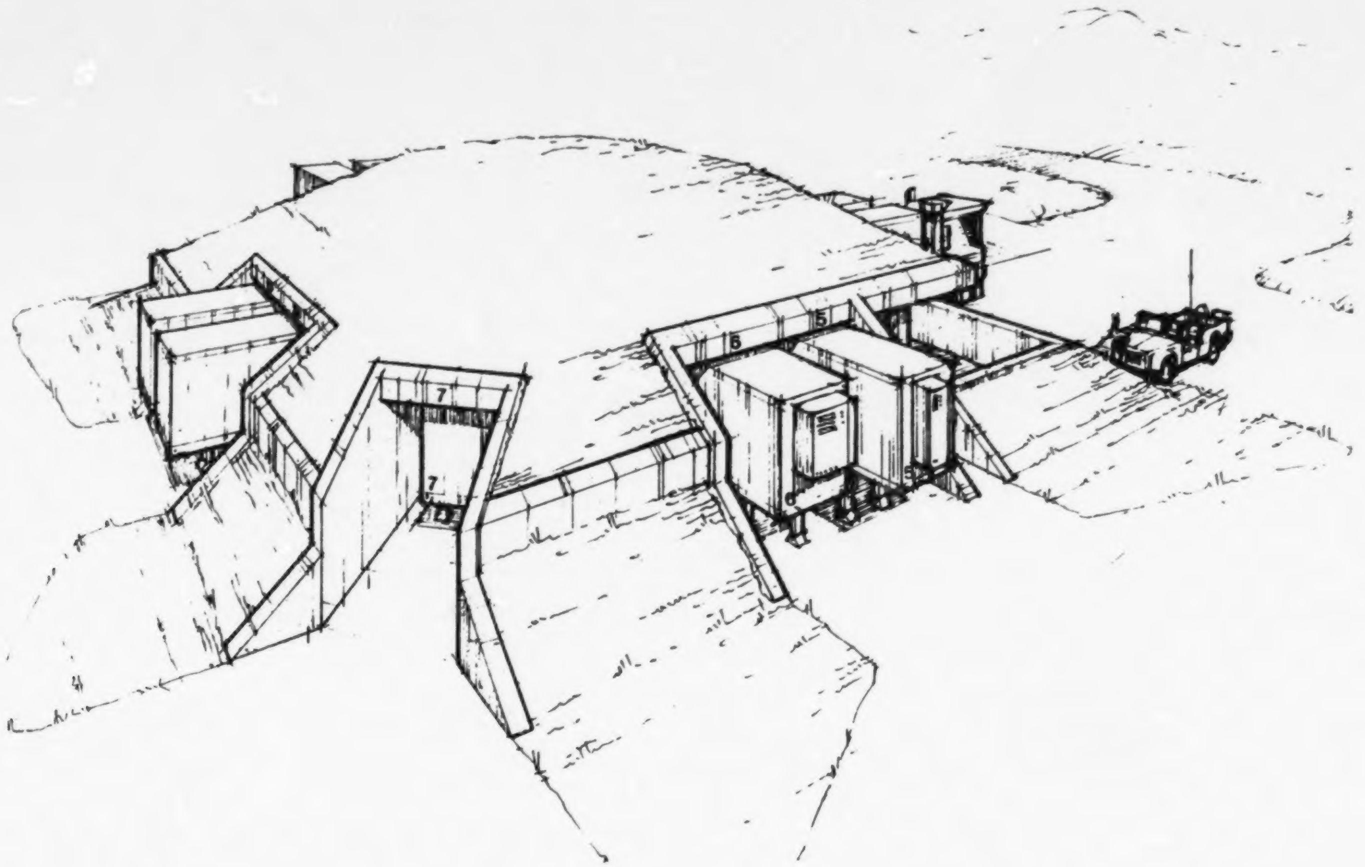
guidance

DCS VAN CENTRAL CONNECTOR (CC)

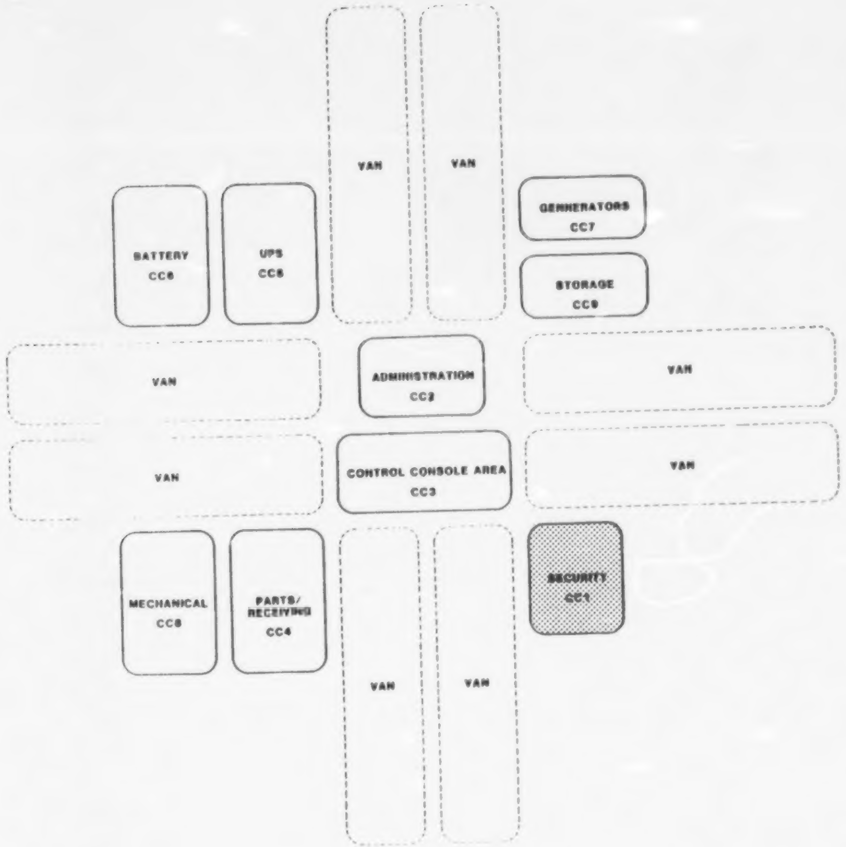
CENTRAL CONNECTOR FOR VANS **CC**

CC1	Security	CC-4
CC2	Administration	CC-10
CC3	Control Console Area	CC-16
CC4	Parts/Receiving	CC-22
CC5	UPS	CC-26
CC6	Battery	CC-32
CC7	Generator	CC-38
CC8	Mechanical	CC-44
CC9	Storage	CC-48
CC10	Standardized Modules	CC-52

CENTRAL CONNECTOR FOR VANS (CC)



SECURITY CC1



function

This component provides overview for verifying visitors before they enter the facility. The Intrusion Detection System and fire alarm equipment are monitored in this area. Also, when required, facility personnel weapons are stored and distributed here.

policy/sop

1. The building site must withstand intrusion by individuals or groups intending to compromise the security of the information transmitted and received at DCS facilities.

2. The overall approach to providing security at DCS sites consists of five elements: (1) intrusion deterrence, (2) intrusion detection, (3) alarm assessment, (4) component and physical plant hardening, and (5) security or response force personnel. Intrusion deterrence is intended to produce a psychological state of mind in a potential intruder that intrusion will result in unacceptable counteraction. Intrusion detection is intended to provide an alarm to the operating activity or security personnel that an unauthorized intrusion has occurred at a DCS site. Alarm assessment is intended to verify that an intrusion alarm was activated by a threat against the DCS site. Component hardening of the physical security system is intended to delay the damages or to limit the amount of damage that can be inflicted on a site. Security force is intended to delay, stop, or mitigate the actions of an intruder. Every DCS site security program shall be prepared to include these five elements. (9) 4.3.3.1

3. The security alarm system should also be wired into either Tech control or the operation area spaces. These spaces will be staffed 24 hours per day, and the same personnel could monitor the security system. The receiving/administrative spaces usually are staffed only 8 hours per day during the week.

4. Most OCONUS sites have local national (LN) guards that maintain security at the perimeter fence during daytime hours. At night this function reverts to site shift communication personnel. All entry alarms should be "remoted" to locations within the operations building similar to that of closed-circuit television (CCTV) monitors. This will preclude assigning critical personnel to security duties. All alarm systems should be "remotable" to the operations console.

issues and assumptions

1. Full-time lighting versus "on-demand" lighting

Continuous lighting (stationary luminaires) is the most common security lighting system. It consists of a series of fixed luminaires arranged to flood a given area continuously with overlapping light cones during the hours of darkness. Standby lighting differs from continuous lighting in that standby lighting is intended to create an impression of activity. The luminaires are not lighted continuously, but are either automatically or manually turned on at random or when suspicious activity is detected or suspected by the security force or the intrusion detection system (IDS). This technique may offer great deterrent value as well as economy in power consumption. (37) 13.1-120

2. Automatic actuation of security lighting versus manual lighting

A deterrent lighting system can be developed to turn lights on at random or, rather than randomly activating the luminaires, an IDS sensor can be used to turn on the lights when an intruder is detected. This type of active lighting system provides maximum deterrent value at a low duty cycle. (37) 13.1-124 Automatic actuation of lights for normal operations seems most advantageous; however, manual override should be provided for control.

activities

1. Viewing personnel entering the complex.
2. Monitoring IDS equipment.
3. Operating facility physical security program.
4. Distributing and storing personnel weapons.

personnel

1. One.

equipment *

1. Pass window for identification.

2. Annunciator panel (sensor information).

3. Closed-circuit TV.

4. Gate control for perimeter security fencing.

5. Exterior lighting control.

6. Communication link to host agency.

7. Alarm for intrusion detection to host agency security office.

8. Desk (or counter unit) with chair.

9. Racks for personnel weapons. Weapon distribution is through a door with a daygate for passing through.

10. Humidifier.

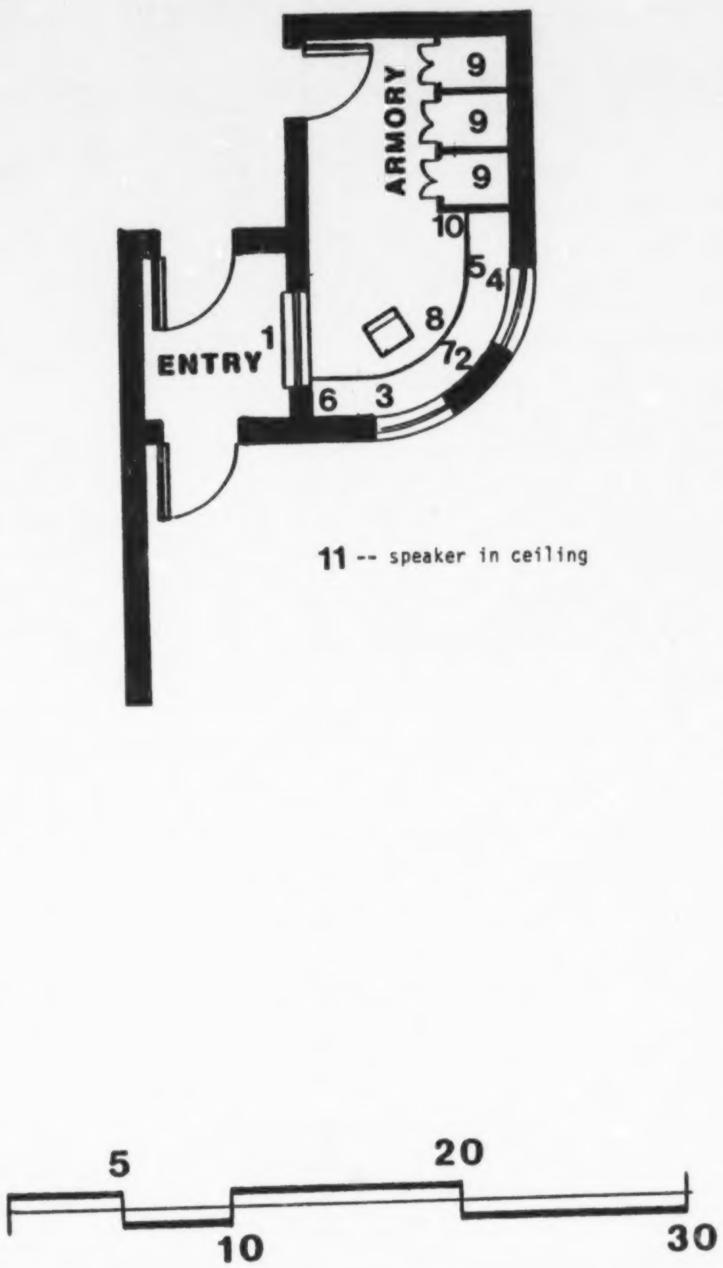
11. Intercom speaker.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate IDS equipment and personnel associated with security component.	**1.** Provide space for one person who verifies and monitors the facility's security. This area varies with size of facility, but typically is 150 to 200 square feet.	
2. Visual verification of entering personnel.	**2.** Provide a pass window.	
3. Communication and electronic monitoring lines.	**3.** Coordinate IDS components into a centralized module. Provide an annunciator panel with telephone and intercom link-ups. The operation room console should have remote alarms along with a CCTV monitor.	
4. Resistance against penetration from the outside and for the armory.	**4.** Windows should be glazed and hardened to prevent penetration (bullet-proof glass). Windows also should be designed for full visibility over approaches to the point of entry.	**4.** See Vol 2, SB7, Security (Zone 3), for more information.
5. Interior finishes suitable for durability, maintenance, and room function.	**5.** Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	**5.** See also Vol 2, SB2, Interior Construction and Finishes.
6. Acoustical isolation and attenuation for a nondisruptive environment.	**6.** The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum), floor surface at NRC .25 (minimum), and divider partitions (if used) at .85.	
7. Adequate lighting to review entering personnel and monitoring equipment.	**7.** Lighting shall be specially engineered. Low levels of lighting may be required to permit observation of luminous panels without reflected glare or undesirable contrasts in brightness. Separately controlled luminaires shall be provided for normally lighted operations and clean-up; this lighting should have an ambient level of 70 footcandles using fluorescent fixtures.	**7.** For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical Lighting.
8. Thermal regulation and other comfort features for the occupant.	**8.** Maintain temperature at 68°F (heating) or 78°F (cooling) with a 5 cubic feet per minute per person outside air ventilation rate. A dehumidifier may be required in the armory. Provide a chair with seat height adjustment, casters, swivel, and independent back rest adjustment.	**8.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
9. Electrical power.	**9.** Provide 120/128 electrical service. 120-volt receptacles should be located for convenience at all workstations and workbenches at the appropriate height and for every 10 linear feet of wall. Frequency levels should be 50 to 60 hertz ± 5 percent.	**9.** See also Vol 2, SB2, Communication Station Buildings--Electrical.

requirements	criteria	commentary
10. Fire protection/life safety criteria are based on the assumption that this facility houses critical equipment and data that has a severe strategic fire loss potential.	**10.** Interior enclosure walls--2-hour fire-rated construction in armory, security, and entry. Interior doors--1.5-hour fire-rated doors in armory, security, and entry. Interior finish--Class A or B only. Corridor and entry finish--Class A only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**10.** See Standardized Modules-Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety for more information.

guidance



11 -- speaker in ceiling

guidance

1. Location

The minimum area is determined from IDS monitoring equipment physical dimensions.

Direct access to facility entrance is required.

This area must have no direct access to C-E equipment.

This component can be combined with the administration function in the small module package.

2. Verification

Orient windows to allow visual security of arriving personnel. In some circumstances, it works well to use mirrors to show the total front face of the building before the door is opened. This also prevents the security officer from confronting unexpected hostile action when leaving.

3. Monitoring

Three shifts in a 24-hour period are assigned for these activities if the personnel are available. At some smaller facilities, the security alarm and detection devices should also be wired into the operations, operations administration, or control monitoring space so that operation shift personnel can monitor the security system when the security space is not staffed.

Alarm system--Provide a wall-mounted alarm terminal panel in the security room. The following alarms will terminate there:

- Smoke/fire detection
- Intrusion detection of all doors and barred openings.

The termination board or its associated housing should have all alarm terminations identified clearly with permanent marking or labels. This allows future extensions of these connections to a control and fault alarm system. The alarm sensors should incorporate only dry contacts (no voltages) and should use two conductor shielded cables in the circuit runs (or in conduit) to the consolidated terminal panel noted above.

Intrusion detection system--The IDS should conform to Corps of Engineers Guide Specification CE 304.01. Provide magnetic intrusion alarm switches on all exterior doors and openings greater than 7.6 feet at the perimeter into the building. Terminate all circuits in the wall-mounted alarm panel. The door alarm is to sound then the door moves 1/2 inch toward an open direction.

guidance

The various approaches to an alarm display problem offer a wide range of capabilities, but also present several distinct disadvantages. In selecting an alarm display system for a specific installation, it is essential that the features and capabilities required for the intended application be well understood. In particular, there is no one "best" system for transmission and display of security information. Rather, a system should be selected to meet the needs of the specific installation. It should also be noted that many systems may provide more capability than is needed or desired and that paying for unused features would tend to increase the system's cost. See Vol 2, SB7, Security Systems, for more information.

4. Primary entrance door

The primary personnel entrance door should be secured with a jimmy-proof, deadbolt extension operated by a combination lock in conformance with UL Standard 768 and Military Specification MIL-L-15596. The primary entrance door should also be equipped with panic bolts and a rim with a box mullion in conformance with Federal Specification FF-H-106. The panic bolts should be UL-approved. If required for routine access control, an electrically controlled latch mechanism is authorized for installation. RF emissions should meet the requirements of MIL-STD-461 of Class II-A equipment when applicable. (5) 3-5-9

The personnel entry doors should be the steel, single-swing type with a steel frame. Another option is a door constructed of hollow metal with a 1/8-inch steel plate face.

Personnel entry doors should also be equipped with a "peephole" wide angle lens. Doors should have an inside plate to cover the peephole when it is not in use.

Hinges on both the exterior personnel and equipment doors must be welded to prevent removal of hinge pins if pivots and pins are on the outside.

7. Lighting design

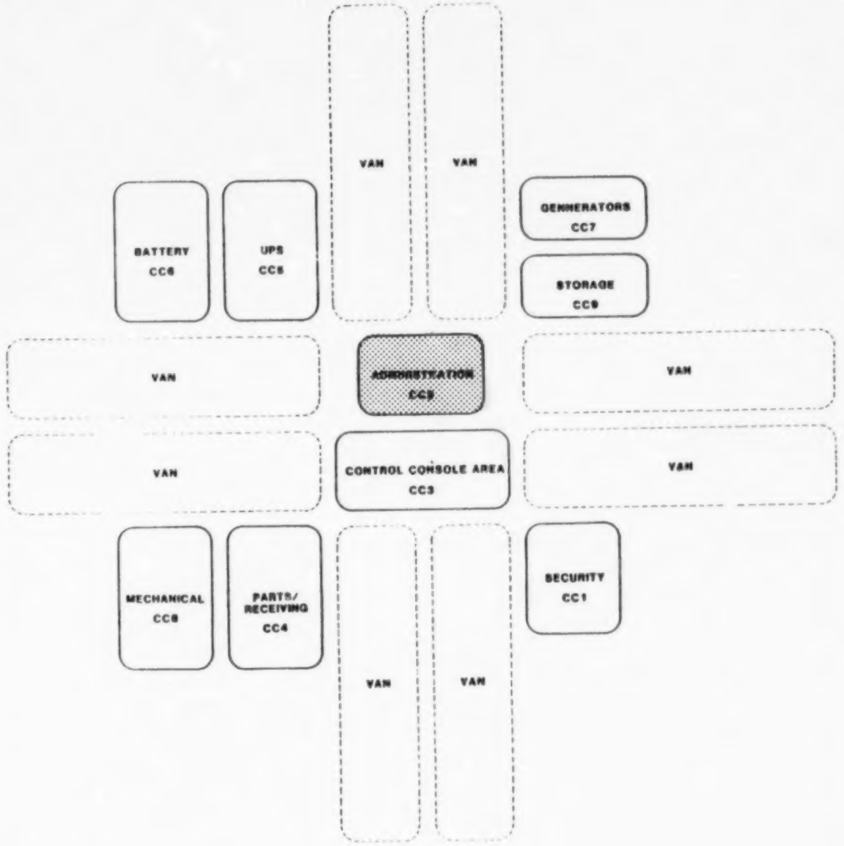
To reduce glare at video digital terminals (VDTs), use fluorescent light fixtures with specular parabolic louvers. A louver with cell dimensions of 1.5 by 1.5 inches or smaller will give a high visual comfort probability (VCP) value. A diffuser along with a parabolic louver may also be helpful. Some pigmented acrylic lenses and nonparabolic metal louver panels can also have high VCP values.

The suggested cell size for a parabolic louver is 1 by 1 inch down to .5 by .5 inch. On tall ceilings, the cell depth must be greater; this may dictate a larger cell size.

Glare from windows and reflections from walls and other surfaces must be controlled, especially on the surface immediately behind the VDT. Walls and work surfaces with a matte finish are best. Wall carpeting is also recommended for its noise control and virtual elimination of reflections.

guidance

ADMINISTRATION CC2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BATTERY
CC6
UPS
CC5
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CC9
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VAN
CONTROL CONSOLE AREA
CC3
VAN
MECHANICAL
CC8
PARTS/
RECEIVING
CC4
SECURITY
CC1
VAN
VAN

function

To establish and maintain the station administrative processing of personnel records and to implement written and verbal standard operating procedure directives from chain of command orders, host agency regulations, and DCA policy for DCS.

The central connector provides the necessary interface between the vans and managing personnel.

policy/sop

issues and assumptions

1. Enclosed office versus open area workstation

Present noncommissioned officers in charge (NCOICs) and the assistants usually occupy an office workstation in the operations room itself. This makes their work more difficult because of the high noise and activity levels. If an enclosed office is provided, a view window to the console area must be provided.

activities

1. Distributing directives, orders and policy statements both written and verbal, to shift supervisors.
2. Initiating evaluation of equipment capabilities.
3. Developing personnel training plans and equipment evaluations.
4. Conferring with personnel (one-to-one).
5. Writing and typing reports.
6. Communicating operations and service functions.
7. Managing the operations function.
8. Planning for exercises and contingencies.

personnel

1. NCOIC and chief-in-charge.
2. Operations NCOIC.

equipment*

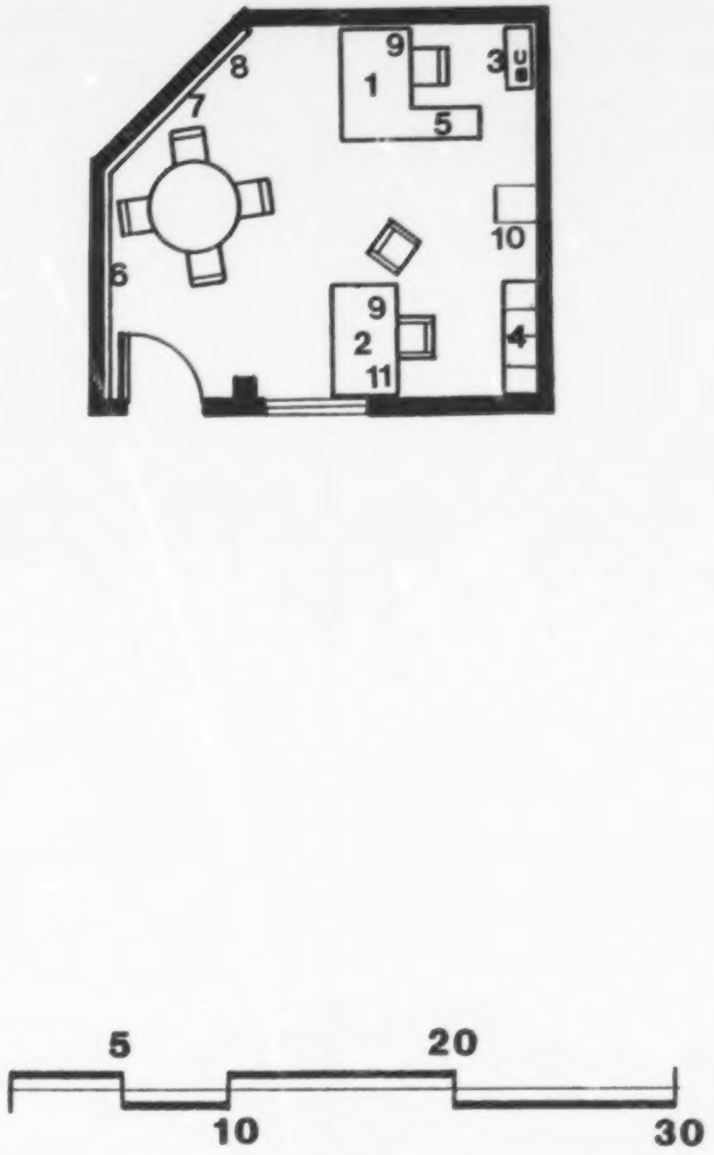
1. NCOIC workstations: desk/chair in open area (or with dividers).
2. Operations NCOIC workstation: desk/chair in open area (or with dividers).
3. Bookshelves--20 linear feet.
4. Four files, five drawers each.
5. Typewriter(s) with stand(s).
6. Tackboard.
7. Scheduling board and multiboard.
8. Station log.
9. Telephones.
10. Filesafe, five drawers.
11. Operational voice intercom control.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate the equipment and furniture associated with the administrative function.	1. Provide approximately 350 square feet.	
2. Visual contact from offices to the operations floor to provide management with better opportunities to optimize personnel effectiveness.	2. Locate the administrative office space adjacent to the operations center console.	
3. Communication lines (outside and inside) for emergency operations and internal interaction between offices and operations floor.	3. Coordinate telephone and intercom needs with the installation.	
4. Interior finishes suitable for durability, maintenance, and room function.	4. Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	4. See also Vol 2, "Site and Building Information," SB2, Interior Construction and Finishes.
5. Aoucstical isolation and attenuation for a nondisruptive environment.	5. The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .90, floor surface at NRC .50, and divider partitions (if used) at .85.	
6. Adequate lighting.	6. Use artificial lighting or natural if present. By quantitative and qualitative evaluation, provide: 20 to 30 footcandles general lighting 60 to 80 footcandles task lighting. Surface reflectances: Ceiling--80 to 90 percent Walls--40 to 60 percent Floors--20 to 40 percent.	6. For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical Lighting.
7. Thermal comfort.	7. Regulate temperature at 68°F (heating), 78°F (cooling), with a 5-cubic feet per minute per person outside air ventilation rate.	7. See also Vol 2, SB2, Communication Station Buildings--Mechanical.
8. Electrical power.	8. Install 120/208 electrical service. Receptacles (120-volt) should be located for convenience at each workstation and workbench at a suitable height for every 10 linear feet of wall. Electrical power must fall within the 10,000- to 500,000-watt range. Frequency levels should be at 50 to 60 hertz ± 5 percent.	8. See also Vol 2, SB2, Communication Station Buildings--Electrical.

requirements	criteria	commentary
9. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe fire loss potential.	**9.** Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**9.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

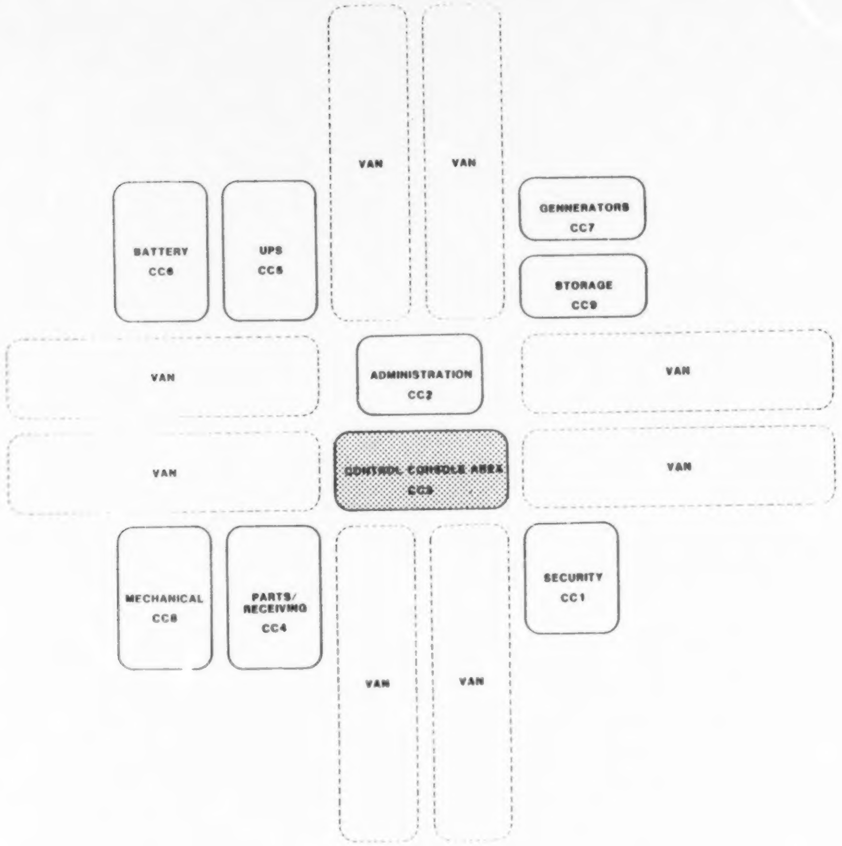
6. Work area

Light fixtures that provide uniform intensity should be equipped with light control lenses or specular parabolic louvers to minimize glare on working surfaces. The work area should also be provided with adjustable task lighting.

guidance

guidance

CONTROL CONSOLE AREA CC3


VAN
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BATTERY CC6
UPS CC5
GENNERATORS CC7
STORAGE CC9
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ADMINISTRATION CC2
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CONTROL CONSOLE AREA CC3
VAN
MECHANICAL CC8
PARTS/ RECEIVING CC4
SECURITY CC1
VAN
VAN

function

To allow personnel to operate, maintain, and monitor communication equipment optimally.

policy/sop

issues and assumptions

activities

1. Monitoring communication equipment (patch and test).
2. Isolating faults.
3. Doing quality control maintenance tests.
4. Troubleshooting and patching to good equipment.
5. Identifying bad connections.
6. Writing/typing reports.
7. Conducting training sessions.

personnel

1. One or two per shift, plus a shift supervisor.

equipment

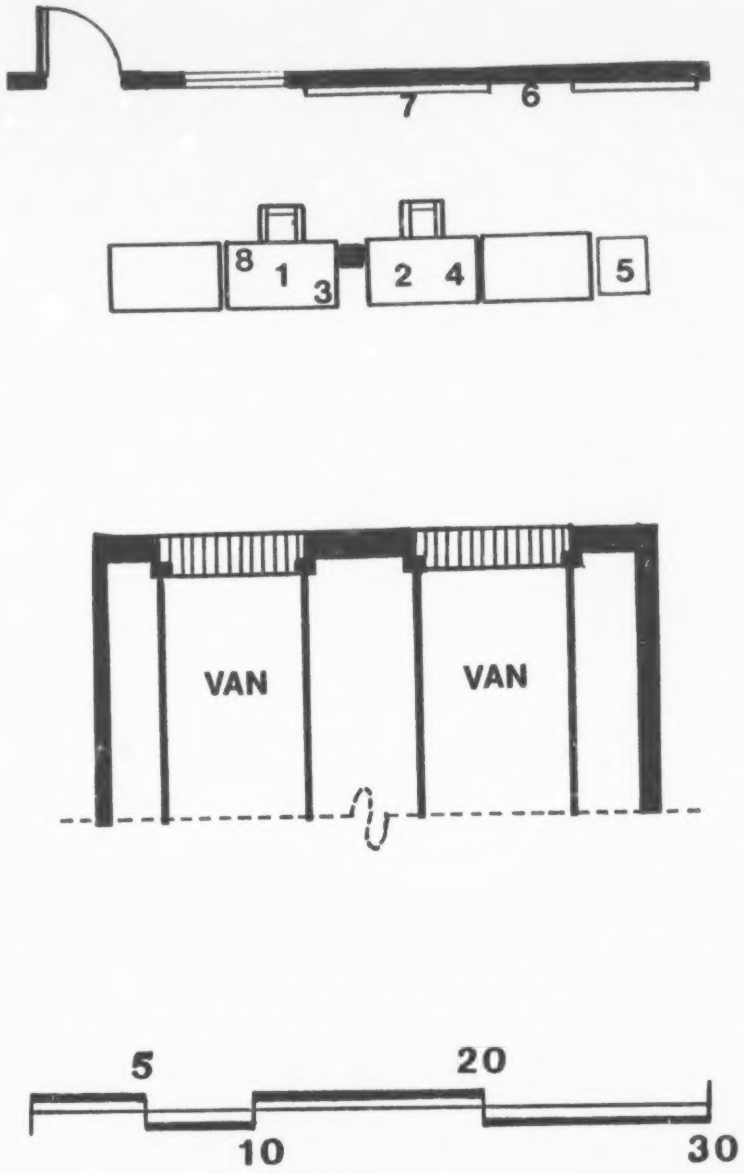
1. Control console and tables with chairs.
2. CRT at desk.
3. Telephones.
4. Typewriter(s)/word processor(s).
5. Filesafe.
6. Electrical shock first-aid kit.
7. Alarm panel.
8. Operational voice intercom control.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for monitoring C-E equipment mounted in vans. Space also must allow for proper viewing into the communication and control vans.	**1.** Provide approximately 700 square feet.	
2. Security for C-E equipment.	**2.** The operations control console area must have an intrusion alarm system. The operations console should be fitted with alarms for intrusion, power failure, and generator status.	**2.** See Vol 2, SB7, Security (Zone 3), for more information.
3. Signal shielding.	**3.** Shielding is required for electrical and electronic equipment to prevent the propagation of interference and to protect against interference propagated by other electronic devices. (15a)/	**3.** See Vol 2, SB4, Grounding, Bonding, and Shielding, along with SB7, Security Systems, for more information.
4. EMP/HEMP shielding.	**4.** Shielding is necessary for survivability and uninterrupted functioning should the facility be subjected to electromagnetic pulse (EMP) and high-altitude electromagnetic pulse (HEMP). Protective measures are based on intercepting the incident energy and dissipating it or reflecting it away from the threatened device, equipment, or facility.	**4.** See Vol 2, SB5, EMP/HEMP Protection, for more information.
5. Interior finishes suitable for durability, maintenance, and room function.	**5.** Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster, and acoustic tiles to within 4 feet of the floor. Ceiling--Acoustic tile.	
6. Adequate lighting.	**6.** Lighting shall be specially engineered. Low levels of light may be required to permit observation of luminous panels without reflected glare or undesirable contrasts in brightness. Separately controlled luminaires shall be provided for normally lighted operations and for cleaning purposes; use fluorescent fixtures that have an ambient level of 70 footcandles.	**6.** For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical--Lighting.
7. Environmental control for proper operation of electronic equipment.	**7.** Temperature shall be maintainable at 70°F (±2°), with 50 percent relative humidity (±5 percent) continuously and 5 cubic feet per minute per person outside air ventilation rate or the outside air quantity necessary to maintain a room pressurization requirement of .05 to .10 water gage.	**7.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
8. Electrical power.	**8.** Provide 120/208 electrical service. Install 120-volt receptacles for every 10 linear feet of wall. Electrical power must fall within the 10,000- to 500,000-watt range, with frequency levels at 50 to 60 hertz ± 5 percent.	**8.** See also Vol 2, SB2, Communication Station Buildings--Electrical.

requirements	criteria	commentary
9. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**9.** Vaulted enclosure walls--2-hour minimum fire-rated construction; shielded construction. Interior doors in vaulted walls--1.5-hour fire-rated doors; shielded doors and frames. Interior finish--Class A or B only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility. Manual emergency equipment power shut-off at exits. Under raised floor area automatic fire detection--Local alarm; automatic Halon 1301 suppression system if cross-zoned or matrix detection is required. Sprinkler and Halon systems are not normally installed in the same areas.	**9.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

1. The van floor elevations shall be the same height as the central connector floor. (52) 2-114 The central connector walls shall be constructed to allow the van doors to be fully opened from the inside of the building. (52) 2-115

6. Light fixtures should provide an approximate uniform lighting intensity of 70 footcandles and should be equipped with light control lenses or specular parabolic louvers to minimize glare on working surfaces. The lights serving the control console area shall be provided with wide-range (100 to 1) dimming control. (23) 12

7. The recommended operating temperatures and humidity conditions for the vans should be obtained from manufacturers of the communications and data processing equipment and should be used in designing the environmental control system.

The central connector height shall exceed the vans' height to provide weatherproofing. (52) 2-114

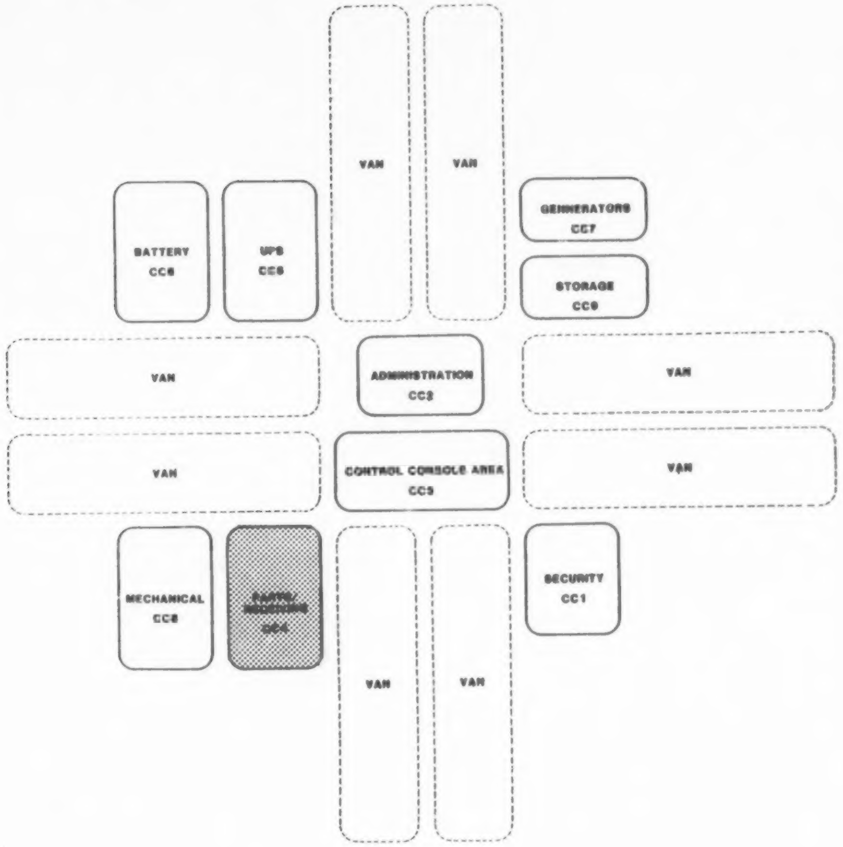
Weather-resistant sealant or barriers shall be installed at the junction of each van and central connector. (52) 2-115

8. A flexible system that will meet the facility's future requirements should be considered for use. Electronic equipment is constantly being upgraded, modified, and replaced. Bus duct systems and cable traps may provide the most flexibility in areas at which new equipment is expected or at which frequent modification may occur. (5) 3-4-8

guidance

guidance

PARTS/RECEIVING CC4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UPS
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GENNERATORS
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CC2
VAN
VAN
CONTROL CONSOLE AREA
CC3
VAN
MECHANICAL
CC8
PARTS/
RECEIVING
CC4
SECURITY
CC1
VAN
VAN

function

This element is the space required to manage all parts supply operations: ordering, receiving, storage, inventory, and security.

policy/sop

1. Requirements for spare parts storage space are determined by the type of equipment at the installation and the level of maintenance to be performed onsite.

2. During preventive maintenance inspections, it may be noticed that some components' performance has deteriorated. Rather than wait for the component to become weaker or to fail completely and cause system interruption, it is considered good maintenance practice to replace the faulty parts during the inspection. Although components would be replaced before their full service life has been realized, service interruptions could be avoided. This practice would, in turn, increase the expected replacement parts cost for an operating system; however, the increase would be justified on the basis of increased system reliability and savings for additional manpower costs that would be incurred in making special trips to unattended stations to restore system operation. (70) 7-49

issues and assumptions

activities

1. Developing parts order lists and working with station Central Supply Office.
2. Receiving, unpacking, shelving of prescribed load list and facility supply parts.
3. Packing and shipping repairable items.

personnel

1. One supply specialist.

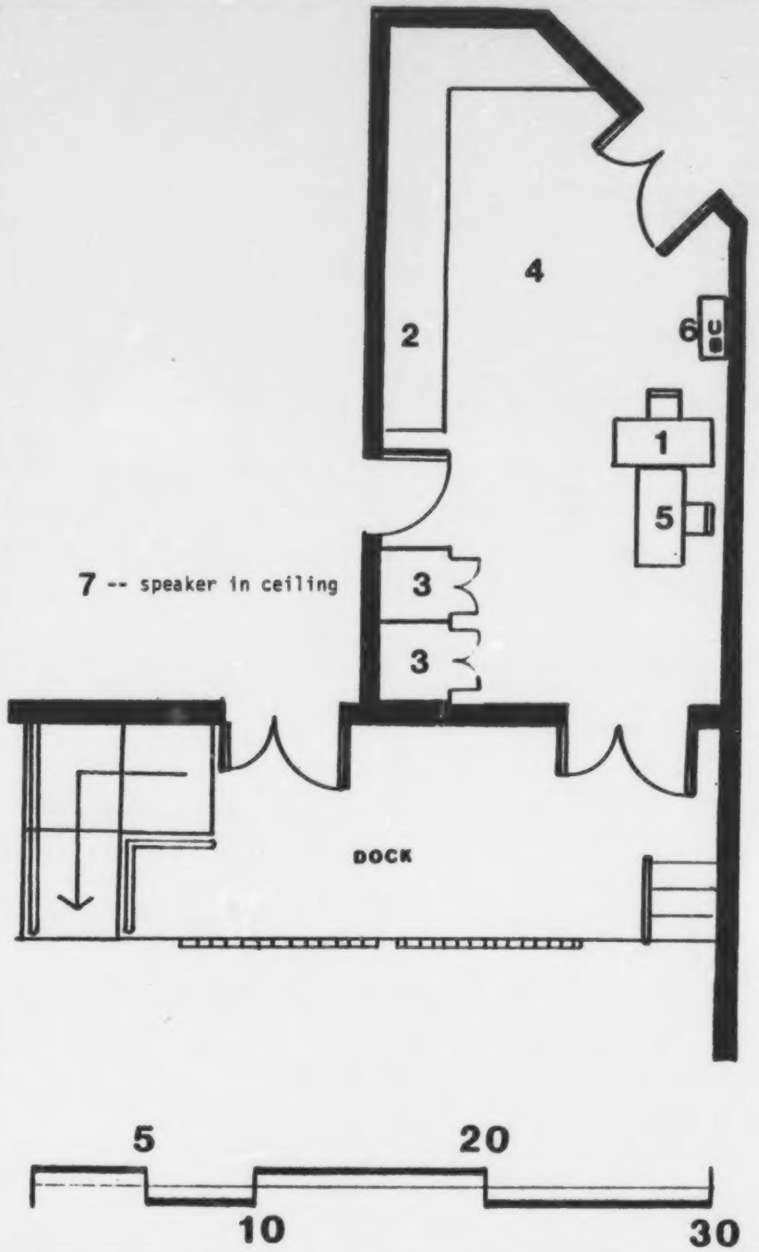
equipment *

1. Table (30 by 60 inches) with chair.
2. Shelving--30 linear feet, floor-to-ceiling type.
3. Three locked cabinets (24 by 36 inches).
4. Open area (100 square feet) for unpacking orders.
5. Desk with chair for parts ordering, microfiche unit.
6. Bookcase for supply manuals--3 to 4 linear feet.
7. Intercom speaker.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for ordering, receiving, and storing C-E equipment. Space must include an open area to facilitate easy receiving of large equipment and supply orders.	**1.** Provide approximately 400 square feet to accommodate storage shelves and to leave an open area for receiving shipments of parts and supplies.	
2. A secure environment.	**2.** This area must be lockable when unstaffed. Provide an intrusion alarm system.	**2.** See Vol 2, SB7, Security (Zone 3), for more information.
3. Interior finishes suitable for durability, maintenance, and room function.	**3.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**3.** See also Vol 2, SB2, Interior Construction and Finishes.
4. Acoustical isolation and attenuation: Acoustical comfort for a nondisruptive environment.	**4.** Adjacent room walls should limit sound transmission to 40 decibels.	
5. Adequate lighting.	**5.** Lighting should be: 20 footcandles (ambient) and 70 footcandles (task).	
6. Environmental control for proper storage of electronic equipment.	**6.** Regulate temperature at 68°F (heating), 78°F (cooling), with a 5-cubic feet per minute per person outside air ventilation rate.	**6.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
7. Electrical power.	**7.** Supply 120/208 electrical service. 120-volt receptacles should be located for convenience at all workstations and workbenches at the appropriate height and for every 10 linear feet of wall. Required frequency levels are 50 to 60 hertz ± 5 percent.	**7.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
8. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	**8.** Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**8.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

1. Location

Locate the parts area between the exterior receiving dock and the maintenance room.

Provide an open area for unpacking equipment before it is moved into operation or equipment rooms.

A loading dock should be designed for a minimum load of 250 pounds per square foot and should provide enough room to maneuver equipment.

2. Door security

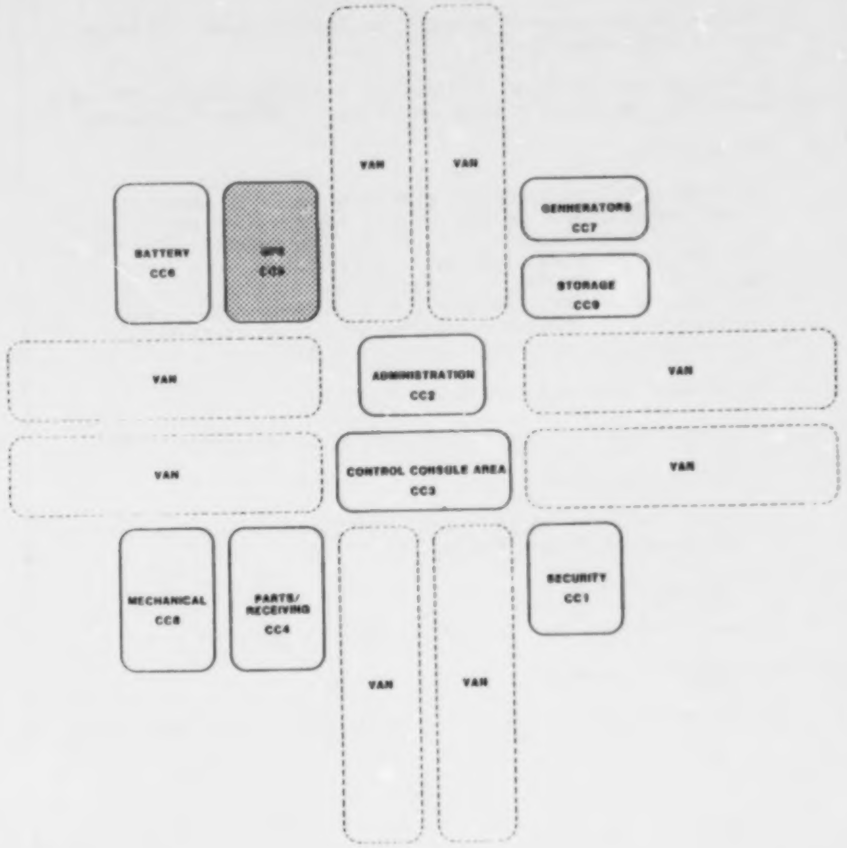
Maintenance/utility doors not permitting entry to administrative/operational spaces should be secured with heavy cylindrical case lock and latch sets in conformance with Federal Specification FF-H-106 and with Builders Hardware Manufacturers Association Standard 601. Doors and hatches that are externally accessible and lead to critical utilities should be secured with padlocks and hasps in conformance with Military Specification MIL-P-43607 instead of or in addition to the cylindrical case or bored locksets specified above. (5) 3-5-9

The hardware set for secure doors should be:

- 1/8-inch-thick drill-resistant hard plate for inside of door
- Secured-type hinges
- Cypher lock with an electronic access control, electric strike, and emergency battery standby
- Combination lock
- Door closer (on each leaf if pair door is required)
- Wide-angle peephole
- Foot bolts and pull-chain bolt for inactive leaf of pair doors.

READEX FICHE

UPS CC5



function

An uninterruptible power supply (UPS) is designed to provide continuous power, without delay or transients, to the critical load.

policy/sop

UPS are characterized by their ability to condition primary or auxiliary power to precise, high-quality power as required by the C-E equipment. UPS maintain continuous power during periods of transfer from one power source to another or for a period long enough to allow for an orderly shutdown. A UPS is required to maintain and provide continuous, conditioned power to the critical C-E equipment and to provide protection from power line transients. The UPS must have the following specific properties.

1. A UPS should serve the critical technical load. It should be solid state with batteries capable of supporting 125 percent of the critical technical load for a minimum of 15 minutes. The UPS is designed to protect equipment from disturbances of voltage and frequency inherent with conventional power distribution systems. The UPS must maintain output voltage and frequency regardless of the nature or severity of the incoming line fluctuations and/or changes in load.

2. The UPS should operate in conjunction with the existing power distribution system to provide quality power for critical technical loads. The system should consist of a solid-state inverter, a battery charger/rectifier, storage batteries, and a static transfer switch with a bypass switch.

3. During normal station operation, the UPS will be supplied with a.c. power by the primary power source--the UPS then changes the a.c. power into a storable d.c. electrical energy to be used as a short-term, no-break power supply for critical equipment. The UPS uses only a small amount of energy to maintain the energy storage levels; the rest is reconverted into a.c. electrical energy. The a.c. power input and a.c. power output of the UPS are isolated from each other by the energy storage medium. A way should be provided to bypass the UPS completely in the event of failure or maintenance. (1) 150

4. The choice of UPS for a vanized facility is more difficult than for a fixed facility. Some older vanized types of equipment do not provide separate distribution networks for critical and noncritical power; this means that if a UPS is used, it must be much larger than for an equivalent fixed installation. (1) 47

policy/sop

5. The power sources and distribution system should be dependable, free from disturbances, and easily maintained. Efficient operation of the earth complex requires a dependable power system that minimizes the number and length of communication outages. Added to the primary objective of dependability are: (a) cost effectiveness to provide the best possible system for the least amount of money and (b) standardization to aid in cost effectiveness, maintainability, and ease of support. Additional information is available in MIL-HDBK 411, AR 420-43, NAVFAC DM-4, NAVFAC DM12.1, AFM 88-15, and the National Electrical Code. (1) 30

6. A modern solid-state UPS is a reliable source of conditioned power. The UPS usually is provided with an electronically controlled static bypass switch when input and output frequencies are identical. The static switch permits automatic bypass if the UPS fails. Also, a manual bypass switch is often provided to permit maintenance on any part of the UPS system. (1) 153 Solid-state UPS have many advantages over mechanical rotary UPS. Bearing, vibration, and low efficiency problems are avoided, and single-point failures are minimized by selection and proper configuration of solid-state UPS. Reserve battery capacity of 15 minutes is normally enough for bringing the UPS online, at which time the auxiliary power plant should be providing the input power. (19) 17

See Vol 2, SB2, for detailed information on UPS.

issues and assumptions

1. Selection of UPS

Single UPS--The single, static UPS has the advantage of simplicity and low cost. The single UPS configuration consists of a rectifier, an inverter, associated controls, protective devices, and an energy storage battery. This system also includes a static bypass circuit that automatically transfers the critical load to the alternate power source without an interruption to the load. When an inverter output failure is sensed, the critical load is transferred to the bypass circuit in less than 5 milliseconds. The synchronous bypass adds about 20 percent to the cost and provides eight to ten times more reliability. UPS failure causes the static switch to transfer the load to the input source, keeping the load online. When selecting this configuration, two conditions must be considered for successful operation: (a) the transfer must be fast enough that the load will not be disconnected and (b) the frequencies and voltages of the primary power and the inverter output must be the same.

Parallel redundant system--This system consists of at least two UPS operating in a load-sharing mode. The output of each is normally connected to the bus through a static interrupter for protection. If an internal fault occurs within an inverter of either system, the static interrupter isolates that inverter from the bus. In case of a bus fault, the interrupter operates in a current limiting mode until the output circuit breaker trips. Parallel UPS may be configured for various combinations of units operating in parallel, such as three units on-line with any two capable of serving the load. Parallel configuration is recommended when the frequency of the primary electric power supply must be converted to serve the critical load such as 50 to 60 hertz.

"Cold" standby independent UPS--This configuration consists of two independent UPS with a common battery. One UPS is online and the other is in "cold" standby. Both UPS are equipped with static bypass circuits that, in the event of UPS failure, automatically transfer the critical load to the primary or auxiliary power source without interruption. The second UPS is then energized manually and placed in the bypass mode and the critical load is assumed by the transfer action of the static switch. The two UPS are not intended to operate in parallel and interlock circuits are provided on the UPS output.

issues and assumptions

2. Float battery systems versus solid-state UPS

The float battery system is the most economical and reliable method of providing continuous d.c. power to critical loads. Since this system is inherently very reliable and since future power sources (renewable energy) provide d.c. power, long-range communications plans call for increased use of d.c.-powered electronics. (19) 10

Floating battery power should be designed for optimal reliability and maximal independence of primary power abnormalities. The battery should be sized to furnish full power to the critical technical load for a period consistent with requirements and system design for auxiliary power capabilities. The battery system supporting solid-state UPS should be sized for 15 minutes in most cases. For 48-volt applications, if specific battery operation requirements are not available, the batteries should be sized for 1-hour operation at attended sites and a minimum of 8 hours' operation at unattended sites. A single float battery system should be designed for all float battery requirements in a common facility. A minimum of two rectifier chargers should be provided. The total number of rectifiers required will be determined by the number needed to supply the load and battery charging current, plus one or more for the maintenance space. When operating on commercial power, the rectifiers should be sized to provide a battery recharge-to-discharge time ratio of not more than 30 to 1. When static inverters are used, provisions should be made to transfer the load gradually from the battery to the primary or auxiliary power source. This provision, normally handled by the rectifier, will minimize transient conditions on the primary or auxiliary power source during the transfer period. (19) 22

activities

1. Doing prescribed maintenance and inspection (PMI) work.
2. Conducting operational checks and load tests.

personnel

1. One, though not located in room continuously.

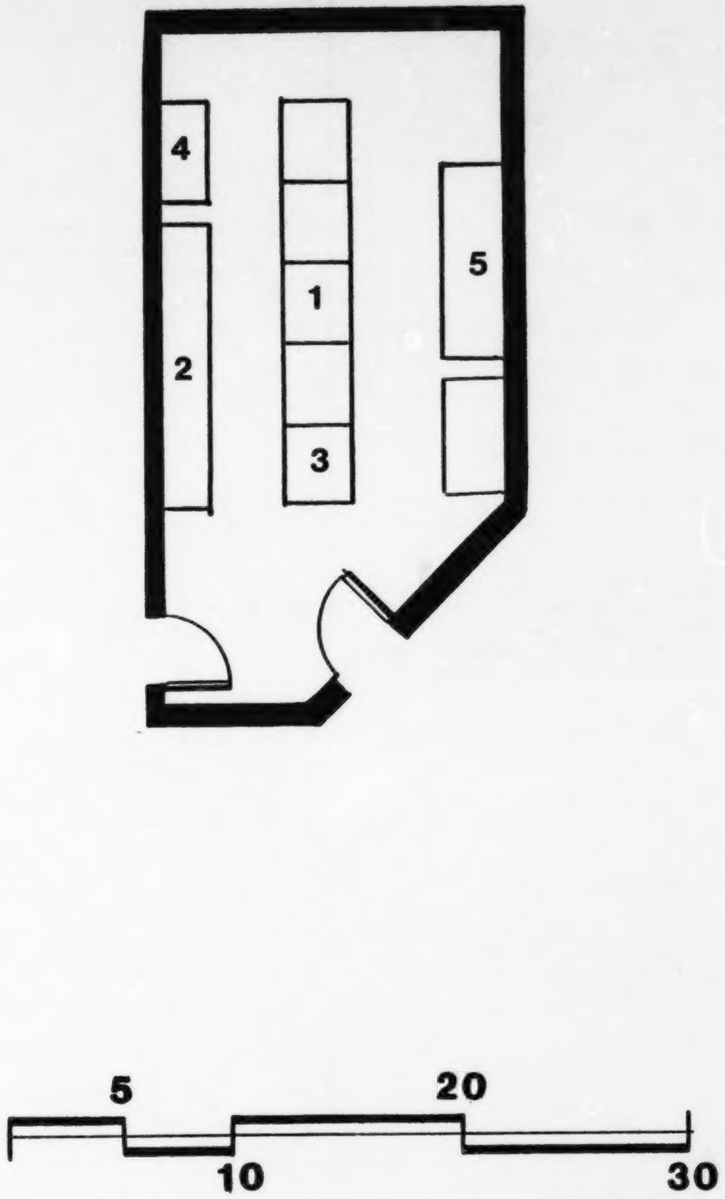
equipment *

1. Solid-state rectifier/charger.
2. Batteries.
3. Inverter, synchronizing equipment.
4. Static switches.
5. Rotary converter (if 60-hertz equipment is used in a 50-hertz host country.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for the operation and monitoring of UPS equipment; proper spacing between equipment for easy maintenance.	**1.** Space needs vary with the communication equipment design (i.e., power requirements), but an average is 400 to 500 square feet. Depending on UPS capacity, certain components are very large and heavy, so consideration must be given to installation and repair or replacement of those items. To accommodate this, knock-out panels may be required. Cable ducts should be located for easy access and drainage.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation and attenuation for variable noise levels produced by electronic equipment.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Adequate lighting.	Provide 20-footcandle (ambient) fluorescent fixtures and 70 footcandles (task) for testing and inspection.	
5. Environmental control for proper operation of electronic equipment.	**5.** Regulate temperature at 50°F for heating. Cooling temperature must be less than 90°F for all solid-state UPS equipment.	**5.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
6. Electrical power.	**6.** Commercial electrical service used in the building will be site-specific. Availability depends on the host country if OCONUS. An outdoor transformer can be installed for UPS spaces in terms of the communication equipment and switchgear. Provide 120-volt receptacles as needed.	**6.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
7. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**7.** Interior enclosure walls--1-hour fire-rated construction. Interior doors--20-minute fire-rated doors. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**7.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

1. Location

The UPS and associated battery should be installed in separate rooms. Construction should be permanent type and the wall separating the UPS should be fire-rated (See Vol 2, SB3). Power continuity during emergency periods of power transfer is maintained by an energy storage battery. Reserve battery capacity of 15 minutes normally is enough for bringing the UPS online, during which time the auxiliary power should be providing the input power.

Structural--Minimum floor load is 150 pounds per square foot. A clear ceiling height of 10 feet should be provided.

Doors--All doors to the UPS room should be constructed of steel and should have a minimum dimension of 4.0 by 7.0 feet. Consider installing a louvered bottom door panel on the interior door(s).

5. Environmental control

Consider installing a solid-state UPS in an environmentally controlled room if adverse environmental conditions exist or if recommended by the UPS manufacturer.

guidance

Figures CC-1 and CC-2 shows the preferred method of heating and ventilating UPS equipment areas, as well as providing the required ventilation system redundancy. The canopy hood, also called a "receiving hood," should be slightly larger than the equipment or exhaust grills in the cabinets and should extend fairly close to them. Direct connections should be avoided unless specifically recommended by the equipment manufacturer. Each exhaust fan should be sized to handle all the air exhausted through the cabinets plus 10 percent (room air) to insure good capture. (5) 3-3-13.

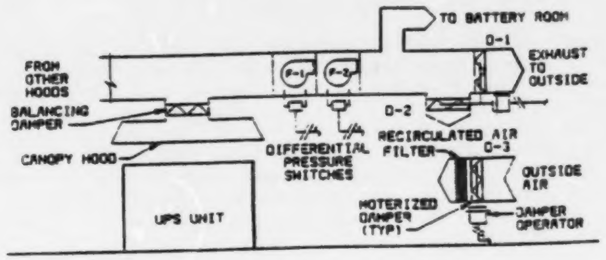

TO BATTERY ROOM
D-1
EXHAUST TO OUTSIDE
FROM OTHER HOODS
F-1
F-2
BALANCING DAMPER
D-2
CANOPY HOOD
DIFFERENTIAL PRESSURE SWITCHES
RECIRCULATED AIR
FILTER
D-3
OUTSIDE AIR
UPS UNIT
MOTERIZED DAMPER (TYP)
DAMPER OPERATOR

FIGURE CC-1. SERIES FAN ARRANGEMENT. (5) 3-3-14

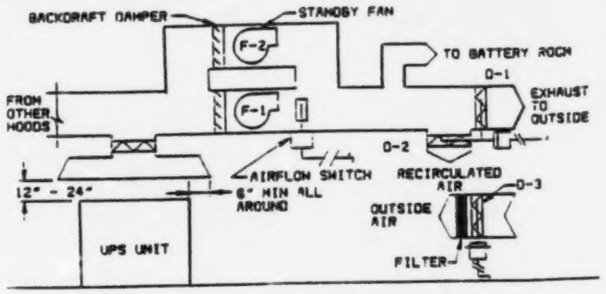
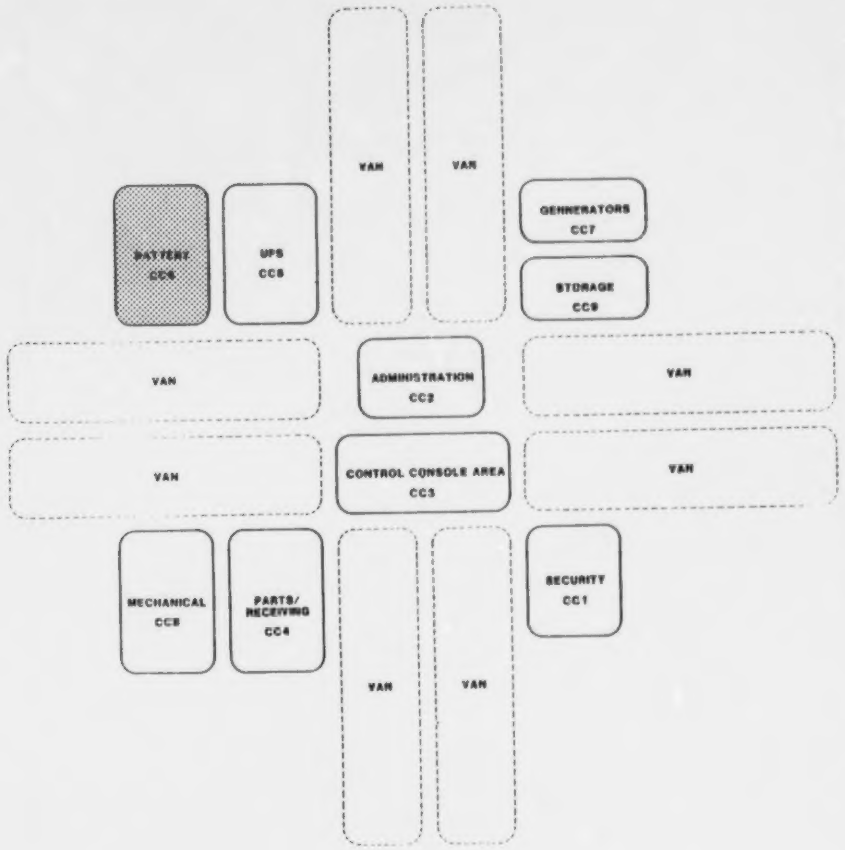

BACKDRAFT DAMPER
STANDBY FAN
F-2
TO BATTERY ROOM
D-1
FROM OTHER HOODS
F-1
EXHAUST TO OUTSIDE
D-2
AIRFLOW SWITCH
RECIRCULATED AIR
D-3
12" - 24"
6" MIN ALL AROUND
OUTSIDE AIR
UPS UNIT
FILTER

FIGURE CC-2. PARALLEL FAN ARRANGEMENT. (5) 3-3-14

guidance

BATTERY CC6


VAN
VAN
BATTERY
CC6
UPS
CC5
GENNERATORS
CC7
STORAGE
CC9
VAN
ADMINISTRATION
CC2
VAN
VAN
CONTROL CONSOLE AREA
CC3
VAN
MECHANICAL
CC8
PARTS/
RECEIVING
CC4
VAN
VAN
SECURITY
CC1

function

The battery room houses batteries that help comprise the backup power system (UPS), a system designed to provide continuous power to the critical load without delay.

policy/sop

1. Battery bank. This should be used as a stored energy source for the UPS. The battery's ampere-hour rating should be high enough to support the inverter for the protection time specified with the mover for operating at rated load. The battery should meet input voltage requirements of the inverter section.

2. Construction. Batteries should be the sealed type, assembled in heat-resistant, shock-absorbing, clear plastic containers with covers cemented in place to form a permanent leak-proof seal. Covers should be fitted with explosion-resistant vent caps. Cell post and cover should be sealed by lead-alloy steel nuts. Cell terminal posts should be equipped with connector bolts that have acid-resistant nuts. Enough sediment space should be provided so that the battery will not have to be cleaned during its normal life. Electrolyte level lines shall be marked on all four sides of the container.

3. Ground protection. The battery should have a high-resistance ground and a ground detection alarm for maximum safety; this will be an integral part of the UPS.

4. UPS batteries should be isolated from machinery in a properly designed battery room to prevent their damage from vibration, pollution, overheating, or explosion.

issues and assumptions

1. Batteries versus generators for "backup" power

The use of batteries as the only backup power is impractical at high-power communications facilities. Some use can be made of batteries for backup at receiving facilities and possibly for low-power (up to 1 kilowatt) transmitter radio facilities, but even this is questionable. Normally, there will be engine-driven generators at the facility to pick up the load within approximately 1 minute of the power failure. Maintaining large banks of batteries for use during an occasional power outage may not be cost-effective. (87) Vol 2, 86

activities

1. Inspecting battery system quarterly.

personnel

1. None assigned fulltime.

equipment*

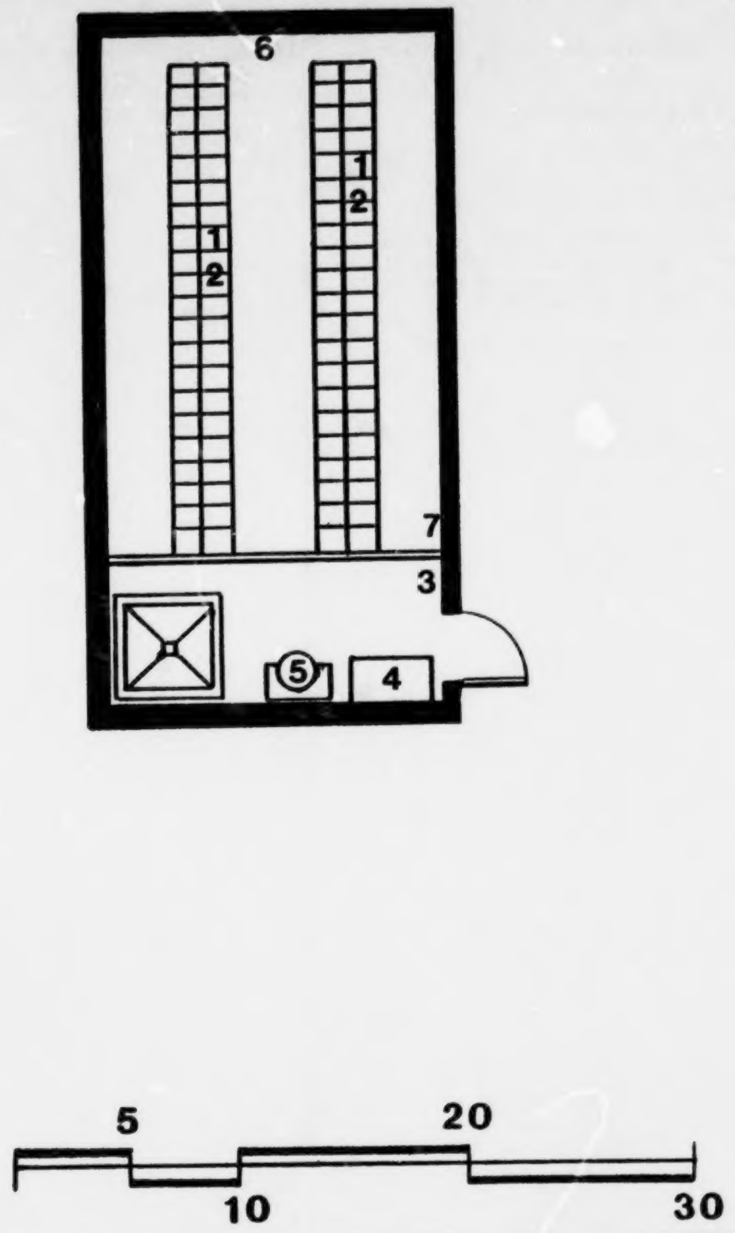
1. Lead acid batteries.
2. Battery racks.
3. Rectifier chargers.
4. Counter workbench for battery maintenance.
5. Emergency eyewash fountain and shower.
6. Safety board, 96 by 48 inches, wall-mounted.
7. Four cans of soda and four jars of distilled water.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for batteries and rectifier chargers to contain the proper safety equipment associated with the battery function.	1. Approximately 450 square feet are needed to provide space for battery racks, rectifier chargers, and the emergency eyewash and shower equipment.	
2. Interior finishes suitable for durability, maintenance, and room function.	2. Floor--Concrete, hardened and sealed. The battery room requires treatment with an acid-resistant floor hardener. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	2. See also Vol 2--"Site and Building Information," SB2, Interior Construction and Finishes.
3. Acoustical isolation for adjacent mechanical equipment rooms that produce variable noise levels.	3. Adjacent room walls should limit sound transmission to 40 decibels.	
4. Acid removal.	4. A special drain system is needed to accommodate acid spills. Provide a curb to contain acid and keep it from entering the shower drainage area.	4. The battery room contains highly explosive fluids and fumes. It is important that item specifications be explosion-proof and meet Occupational Safety and Health Administration (OSHA) regulations.
Safety board.	5. Use 96- by 48-inch mounted board for assigned safety gear and a large enough floor area to store four cans of soda and four jars of distilled water.	
6. Separate exhaust ventilation system to outside.	6. An interlock must be provided to deenergize charging circuits if ventilation fails or shuts down. See SB2, Special Mechanical Systems, for ventilation rates.	
7. Adequate lighting.	7. Use 60-footcandle fluorescent lighting in corrosion-proof fixtures.	
8. Thermal comfort.	8. Maintain temperature at 60°F for heating. 104°F is the maximum allowable temperature.	8. See also Vol 2, SB2, Communication Station Buildings, Mechanical.
9. Electrical power.	9. Provide 120/208 electrical service. All 120-volt fixtures and switches are to be Class II. Locate one receptacle for every 10 linear feet of wall. Metal battery racks will be grounded to the earth ground system. (Explosion-proof electrical receptacles and fixture explosion venting are not required, but are recommended.)	9. See also Vol 2, SB2, Communication Station Buildings, Electrical.

requirements	criteria	commentary
10. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**10.** Interior enclosure walls--1-hour fire-rated construction Interior doors--20-minute fire-rated doors Interior finish--Class A or B only Automatic fire suppression--Water sprinklers Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility Explosion-proof electrical receptacles and fixture explosion venting.	**10.** See Standardized Modules--Building Design Principles and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance


6
1
2
1
2
7
3
5
4
5
20
10
30

guidance

1. Location

Battery rooms, consisting of cells mounted on manufacturer-supplied battery racks, are normally adjacent to the UPS equipment room. The battery room should be windowless, reasonably well insulated against heat loss and gain, and located to minimize solar gain. Frequency conversion equipment should be as close as possible to the equipment it serves. Motor generators should be located in a separate room to reduce noise levels and heat gains in operating spaces. Static converters can be located in the equipment space or operating space because they produce minimal heat and noise. (92) 12.1-12

Spatial needs

The 48-volt d.c. battery set consists of 24 cells with interconnections, mounted in a two-tier seismic-resistant rack. (Figure SC-3.)

A suitable galvanized steel rack should be furnished. Lead-plated copper interrack connectors and cell numbers should be provided. Plastic covers should be provided to insulate rails and cells. Racks should be painted with two coats of acid-resistant paint.

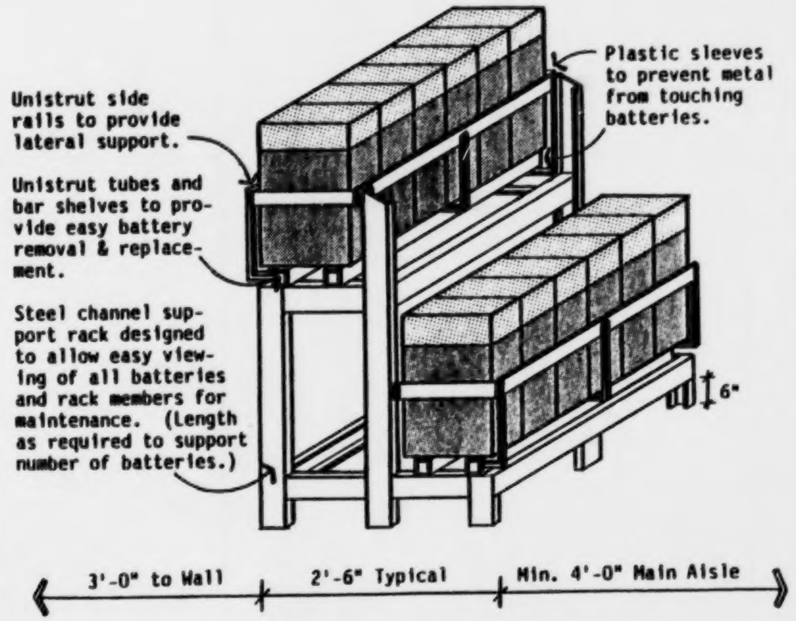

Unistrut side rails to provide lateral support.
Unistrut tubes and bar shelves to provide easy battery removal & replacement.
Steel channel support rack designed to allow easy viewing of all batteries and rack members for maintenance. (Length as required to support number of batteries.)
Plastic sleeves to prevent metal from touching batteries.
6"
3'-0" to Wall
2'-6" Typical
Min. 4'-0" Main Aisle

FIGURE CC-3. TYPICAL BATTERY STORAGE RACK

guidance

The 48-volt d.c. power can consist of two, three, or four rectifiers with storage batteries sized properly to meet each site's power requirements. The rectifiers can be operated in a parallel/redundant mode, which extends the equipment life and provides uninterrupted service should one cell fail. Rectifiers should have a "current walk-in" feature for a smooth increase in current with initial power-up to protect the load and prevent accidental circuit breaker tripping. Rectifiers also should have a current limit control that can be adjusted from 90 to 125 percent to limit the output current. A voltmeter and an ammeter can indicate rectifier operation and front panel alarm lights are available for external monitoring. Battery plant capacity should be sized to support the total load. (88)G-1

2. Durable surfaces

All floors, walls, and ceilings should be made of acid-resistant materials. Exposed concrete is recommended for the floor.

All doors to the battery room should be constructed of steel and should have a minimum dimension of 4.0 by 7.0 feet (1.22 by 2.14 meters). Consider installing a louvered bottom panel on the interior door(s).

Exhaust fans in the battery room should be covered with security bars. See SB7 in Vol 2.

The battery room floor design load should be 250 pounds per square foot (1220 kilograms per square meter).

4. Acid removal

All required actions must be taken to meet host country laws and regulations against the water and air pollution. Plumbing systems must be in accordance with DIN standards.

An acid-resistant drain line should be installed between the battery room floor drain and the holding tank for chemical waste. Connection to sewage lines should be avoided. Vent lines also should be acid-resistant.

6. Exhaust ventilation

The battery room is to be supplied with its own ventilation intake and exhaust ports to outside air. (40) 6-8

The central ventilation system supporting air to and exhausting air from the building can be used to supply air to the battery room for exhausting to the outside. (40) 6-8

Battery rooms shall be ventilated with nonsparking exhaust fans to maintain a stable room pressure that is lower than that in adjoining rooms to prevent the outflow of contaminated air to other rooms. Required outdoor air ventilation rates for batteries and equipment shall be obtained from the manufacturer and shall be used in designing the environmental control system.

guidance

The battery room is normally ventilated by wall fans or power roof ventilators. Fans are sized so that either is adequate to limit hydrogen gas buildup to 2 percent. Both fans should have manual starters. If wall-mounted, they should be high enough to avoid hydrogen buildup near the ceiling. Backup electrical unit heaters sized to maintain a minimum temperature of 60°F (15°C) should be provided for times when waste heat is not enough to maintain the battery room temperature at its winter design level. Heaters should be on the utility or normal power circuit.

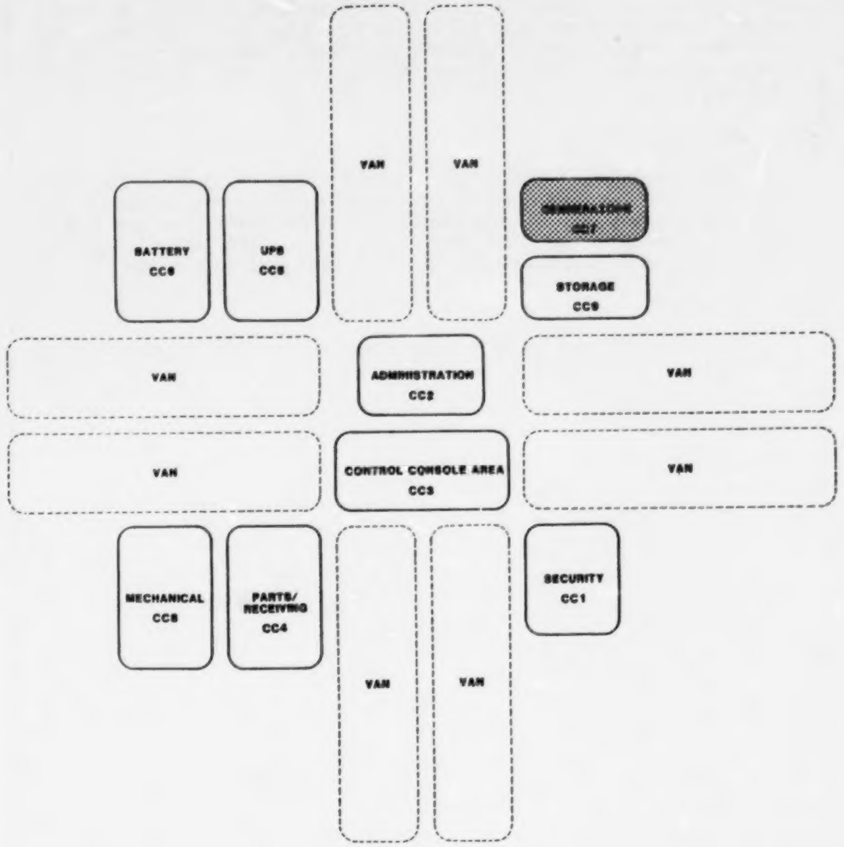
7. Lighting design

Explosion-proof fluorescent lighting fixtures meeting DIN standards should be installed in the battery room. Lighting levels in the battery room should be no less than 30 footcandles (324 lumens), as measured 30 inches (75 centimeters) from the floor. The light switch should be located outside of the battery room on the wall next to the door.

10. Life safety

A combination emergency deluge shower and eyewash fountain should be installed in the battery room.

GENERATOR CC7



function

To maintain power to all communication systems when commercial power fails.

policy/sop

1. Primary power requirements for a communications facility are determined by the system configuration and include equipment loads (technical power), utility and domestic loads, and provisions for future expansion. The contracted architectural engineering agency is responsible for designing the site primary power system and its distribution. One of the most economical, convenient sources of auxiliary power is the diesel-engine generator. However, an engine-driven-generator requires time to start and warm up, allowing a delay before taking the load after a power failure. Recommended practice is to use storage batteries to provide power instantly and economically. These batteries are kept fully charged by the primary power source during normal operation and, when failure occurs, they assume the load instantly without interruption to service. Batteries cannot supply power for long periods, however, making it necessary to have an auxiliary generator available. (70) 15-11

2. On-station prime power plants are considered only when the local power is either extremely unreliable or expensive, when no power is available, or when self-sufficiency is required for survivability and reliability in a wartime environment. On-station prime power plants normally use multiple sets of DOD standard family, diesel-engine generator sets for the power source. Other sources (such as wind turbines, thermoelectric generators, fuel cells, gas turbine generators, steam turbine generators, and nonstandard diesel engine generators) also can be used and should be considered when requirements for a wartime DCS dictate. An on-station prime power plant will use a minimum of three engine generator sets, with one set online and carrying the station load, one as a standby, and one as a maintenance spare. A more reliable configuration is to use four or five generator sets, with two sets online in a load-sharing mode, one as a cold standby unit, and one or two as maintenance spares. When the station's standby power requirements exceed 70 percent of the total power requirements and the standby power is redundant, a study should be done in accordance with DOD 4270.1-M to determine if it will be more economical to provide a total energy system that produces both electrical and steam power to be used as needed. (1) 31

3. The auxiliary power source for a vanized facility usually will be the same as for a fixed facility. However, for temporary installations that will not be replaced by a fixed installation, the on-station auxiliary generator plant normally will not exceed two DOD standard family generators. (1) 47

policy / sop

percent of the total power requirements and the standby power is redundant, a study should be done in accordance with DOD 4270.1-M to determine if it would be more economical to provide a total energy system that produces both electrical and steam power to be used as needed. (1) 31

4. Site personnel efficiency will be improved if it is possible to locate noisy mechanical equipment, like some diesel generators, away in housing separate from working and living areas or if some other type of noise control is provided. Also, care must be taken to insure that fresh air intakes do not catch fumes or odors from sources such as diesel generators. (2) 5-25

5. All onsite power sources (generators) and substations should be located at a point in the station boundary for which security is adequate. Additional guidelines for locating power sources and substations are: (1) 32
   a. The primary onsite power source should be located far enough from the station work areas to insure acceptable noise levels as outlined by the acoustical noise requirements of MIL-STD-1472.
   b. The primary substation should be located for convenient delivery of power from an off-station source and for easy distribution of the power to onsite facilities as required.
   c. Distribution substations should be located as close as possible to the parts of the operating building they serve.

6. Total fuel storage tank capacity should be determined by local replenishment opportunities, but should hold at least a 30-day supply. The storage tank(s) should be constructed of fiberglass and, when practical, installed underground on an incline to prevent sediment accumulation. Provisions should be made for easy filling and removal of water and other sediment. (19) 13

issues and assumptions

1. Commercial power versus generators

The mission of DCS communication facilities is to provide reliable communications 24 hours per day. Ideally, the power source for the mission equipment should be reliable, well regulated, easily maintained, and free of transients and disturbances. In actual practice, these desirable characteristics are seldom achieved on a long-term basis. Other factors to be considered in the choice of a facility power supply are:

   a. Providing the best possible system for the least amount of money (cost effectiveness).
   b. Standardizing for better cost effectiveness.
   c. Providing easy support (maintainability). (87) Vol 2, 62

Normally, a DCS communications facility will operate from commercial power using local generators for backup. In some areas of the world, however, commercial power may not be available or if it is, it may be so unreliable as to be unusable for the technical load. Such supplies may be satisfactory for the nontechnical load (area lighting, housing, etc.). In such cases, the primary power source should consist of generators located on the facility site. (87) Vol 2, 83

2. Comparison of engine generators

The selection of an engine generator to supply an independent power source (primary and/or standby) depends on several factors. The choice is usually between a diesel and a gasoline engine. Each has properties that determine its suitability for a particular application.

The diesel engine is suitable for either continuous or part-time service. Initial cost is slightly higher than that of a comparable gasoline engine; for certain applications, however, this disadvantage is more than offset by advantages. The diesel engine is extremely rugged, uses less and lower cost fuel, has a long life expectancy, and offers maximal reliability. Reasons for these advantages include (a) diesel fuel has a higher energy content than gasoline or liquid petroleum, (b) diesel engine operating speed is approximately half that of the gasoline engine, and (c) the diesel engine does not require an electrical ignition system. The last two factors account for lower maintenance and overhaul costs for the diesel engine. Engine starting time is comparable for diesel and gasoline engines.

Gasoline engines can be used for continuous power, but are better suited for standby use. As mentioned previously, the gasoline engine has a lower initial cost, but also a shorter life expectancy. It has a higher operating speed, which wears out the engine more rapidly. It uses more and higher operating speeds, which also wear the engine out more rapidly. It uses more and higher cost fuel and is not as reliable as a diesel engine. One reason for poor reliability is that a gasoline engine uses an electrical ignition system which is subject to failure due to dampness, age, and carbon buildup. (70) 14-3

issues and assumptions

3. Level of maintenance performed

If depot level maintenance is required and authorized, an open area, benches, and special tools (torque wrenches) also are required in the generator room. This is especially true at Navy installations, which require more extensive repair onsite.

4. Above-ground versus below-ground oil storage tank

To insure protection from hostile attack, below-ground tanks provide better security for the standby power system; however, above-ground tanks are cleaned, repaired, and maintained more efficiently, effectively, and economically.

5. Sizing generator fuel tanks

Engine generator size depends on the station's power requirements. The fuel tank capacity for these units depends on the site's accessibility and the size of the engine generators. It should not be necessary to refill fuel tanks more than once a month. If inclement weather or undue hardship dictates a longer period of time between refuelings, a larger tank is recommended. The approximate rate of fuel consumption of a diesel-driven generator, in gallons per hour, can be calculated by multiplying the output in kilowatts by 0.136; this calculation will be helpful in determining the size of tank needed. (70) 14-2

activities

1. Starting the on-line generators after commercial power failure.
2. Repairing and maintaining generators.

personnel

1. Two personnel, though not in room continuously.

equipment**

1. One "set" of generators.* (Usually Class C.)
2. Batteries for start-up.
3. Fuel tank with dispensing pump. (Tank capacity varies with size of generators and reliability level of primary commercial power.)

   See MIL-HDBK 411 for the specific capacity in relationship to a class of generators.
4. Alarm panel.

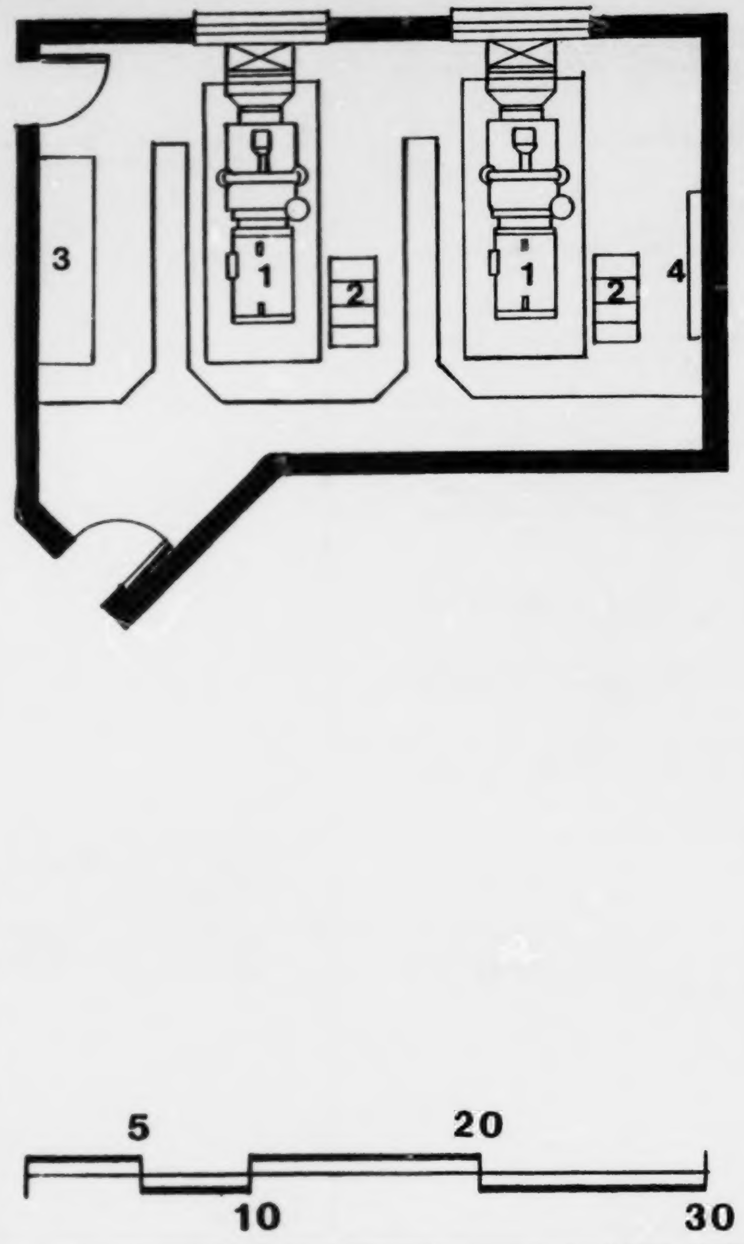
---

*The number and size of generators will vary among facilities depending on the voltage required to maintain the mission.

** see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for the installation, removal, and repair of standby generators.	**1.** Space needs vary with power requirements (see guidance drawing). Allow approximately 500 square feet for two generators.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustic isolation for variable noise levels produced by mechanical equipment.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Generator operation indicator and alarms.	**4.** An alarm and operation indicator panel will be located at the control console area of the operations space.	
5. Emergency lighting.	**5.** Emergency lighting should be bright enough to allow switch gear operation, instruction reading, and other mission-essential activities.	
6. Environmental control to provide generators' constant supply of make-up air for combustion and cooling.	**6.** Provide automatically adjusted louver units sized for capacity of generator selected. Exhaust stacks must be caged to prevent bird/animal entry.	
7. Vibration control.	**7.** The generators must be placed on a concrete pad physically isolated from the main floor.	
8. Design that allows complete removal and exchange of generator units.	**8.** Air intake/exhaust units should be located and sized to become a "knock-out" panel for removing a complete generator.	
9. Adequate lighting.	**9.** Use 40 footcandles (ambient). "Slow start" fixtures such as mercury vapor should not be used, nor should fluorescent fixtures.	
10. Thermal comfort.	**10.** Regulate temperature at 50°F for heating.	**10.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
11. Electrical power.	**11.** Provide 120/208 electrical service. Install 120-volt outlets; at least two duplex receptacles are required at workbench areas and at the appropriate height. Use 240-volt receptacles when required.	**11.** See also Vol 2, SB2, Communication Station Buildings--Electrical.

guidance



guidance

1. Location

If a standby generator is to operate continuously for instantaneous commercial power backup, the generator room should be located away from all normal operational spaces to isolate the noise.

Clearances--All ducts and other systems installed in the facility as part of the finished structure should be arranged to maintain a 10-foot unobstructed clearance from the floor to the ceiling.

Structural--Isolate the foundations of each generator. The generator room floor design load should be 500 pounds per square foot within an isolated generator block that has a steady load of 4000 pounds. It is recommended that pad dimensions exceed diesel engine dimensions by 25 to 30 percent.

Doors--All single doors should be constructed of steel and should have a minimum dimension of 4.0 by 7.0 feet. The exterior equipment door for the generator room should be double-wing type with minimum dimensions of 6.0 by 7.0 feet. This door should be equipped with a drop-in horizontal bar to secure it from the inside.

Storage tank--When required, provide an underground fuel oil storage tank adjacent to the power/mechanical room. Also provide fuel oil supply and return lines, fill pipe, oil level gage, and alarm conduits. This tank must be equipped with a float switch to activate an alarm indicating a low fuel oil condition.

A single storage tank should be provided for a minimum 15-day supply for both the heating boiler and diesel engine generators. A fiberglass underground tank should be used. A day tank should be provided in the building to supply fuel to both the heating boiler and diesel engine generators. (See also Vol 2, SB1, Site Planning and Development.)

Provide floor trenches in the power/mechanical room for supply and return fuel lines from the exterior fuel oil storage tank and for cable runs from the generator to the transfer switch and main distribution panel. Floor trenches should have 0.25-inch-thick steel plate covers.

guidance

4. Alarm system

Provide a wall-mounted alarm terminal panel in the generator room. The following alarms will be terminated there:

- Generator status
- Commercial power status
- Low fuel oil level (48-hour supply)
- High (80°F) or low (55°F) temperature status in communication equipment and power mechanical room
- Generator start failure.

The termination board or its associated housing should have all alarm terminations identified clearly with permanent marking or labels for future extensions of these connections to a control and fault alarm system. The alarm sensors should incorporate only dry contacts (no voltages) and should use two conductor shielded cables in the circuit runs or in conduit to the consolidated terminal panel noted above.

Provide adequate grounding cable from the building ring ground system, when applicable, to the diesel generator set metal frame and to the underground fuel oil storage tank. See Vol 2, SB4.

6. Environmental control

Generator exhausts should be located such that fumes will not be sucked into other HVAC air intakes. Emergency generators can be located inside the operations building if they are isolated properly from the rest of the structure in terms of fire protection, sound attenuation, and vibration control. (92) 12.1-12

Louvers and Openings

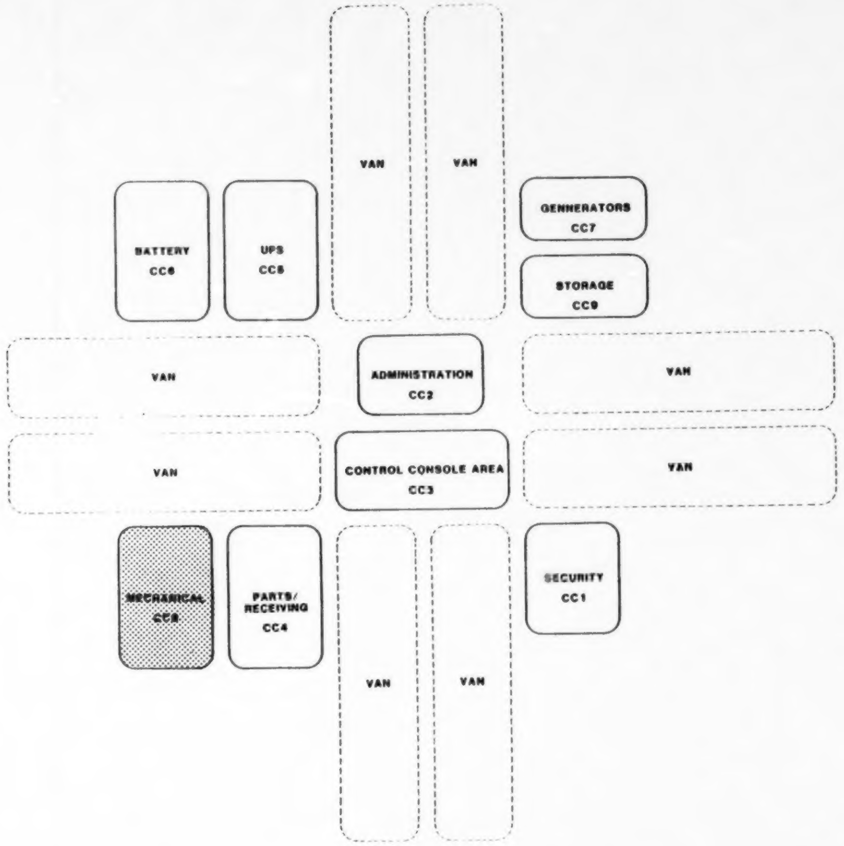
Provide motorized air damper openings in the generator room walls to accommodate diesel engine combustion air requirements.

Provide security bars on all openings subject to physical intrusion (greater than 7.6 feet in perimeter) such as air intake and exhaust louvers. Their attachment to the structure must be nonremovable from the exterior.

See Vol 2, SB7, for security guidance.

guidance

MECHANICAL CC8



function

This module provides space for equipment to supply all the heating, ventilating, and air-conditioning (HVAC) and water requirements for the entire facility. It must also be flexible and spacious enough to accommodate alternative energy sources.

policy/sop

1. It is desirable to provide a separate room for mechanical equipment such as heat exchangers, air-conditioners, and waveguide dehydrators-pressurizers. Heat exchangers must have air intake and exhaust ducts to the outside of the building. The size of these ducts dictates that heat exchangers must be located close to the wall. It must not be overlooked that some types of heat exchangers may require rear access for maintenance. Location of the dehydrating-pressurizing equipment is not critical. However, ease of access for maintenance is desirable and the pressure gages should be readily visible to the maintenance personnel. The air-conditioning equipment location will depend on the specific type provided and whether or not intake and outside exhaust are required. (2) 5-24

2. Cable/pipe trenches with metal cover plates will be considered for use in areas to house transportable/mobile equipment systems. If used, trenching will be on a grid system and will be sized to accommodate chilled water pipes, drain lines, power cables, signal lines, etc., as appropriate. The metal cover plates will be able to withstand wheel loads of a 15K forklift. The metal plates will be removable and a size/weight such that no more than two persons will be required to remove a plate. The trenching will include metal brackets for mounting power distribution breaker boxes. Trenches, if used, will be sloped to one or more sumps within the equipment systems parking area in which forced or gravity drains will be provided.

issues and assumptions

1. Calculation of space requirements

   a. Heating for each area of the facility is commonly provided by an oil-fired hot-water boiler located in the mechanical equipment room. During the heating season, hot water is supplied from the boiler to the various heating, air-conditioning, and domestic hot-water systems. In the summer, domestic hot water is provided by a small oil-fired hot-water heater and the boiler is turned off. This arrangement will add to boiler efficiency and energy conservation.

   b. Provisions will be made in the mechanical equipment rooms to allow for removal of tubes from boilers and chillers as well as the removal of coils and filters from air handling units for maintenance and replacement. All equipment will be located to allow easy access for maintenance and servicing.

   c. Usage will be 24 hours per day, 7 days per week. No special provisions for peak usage are required.

activities

1. Maintaining, controlling, and inspecting mechanical equipment.

personnel

equipment *

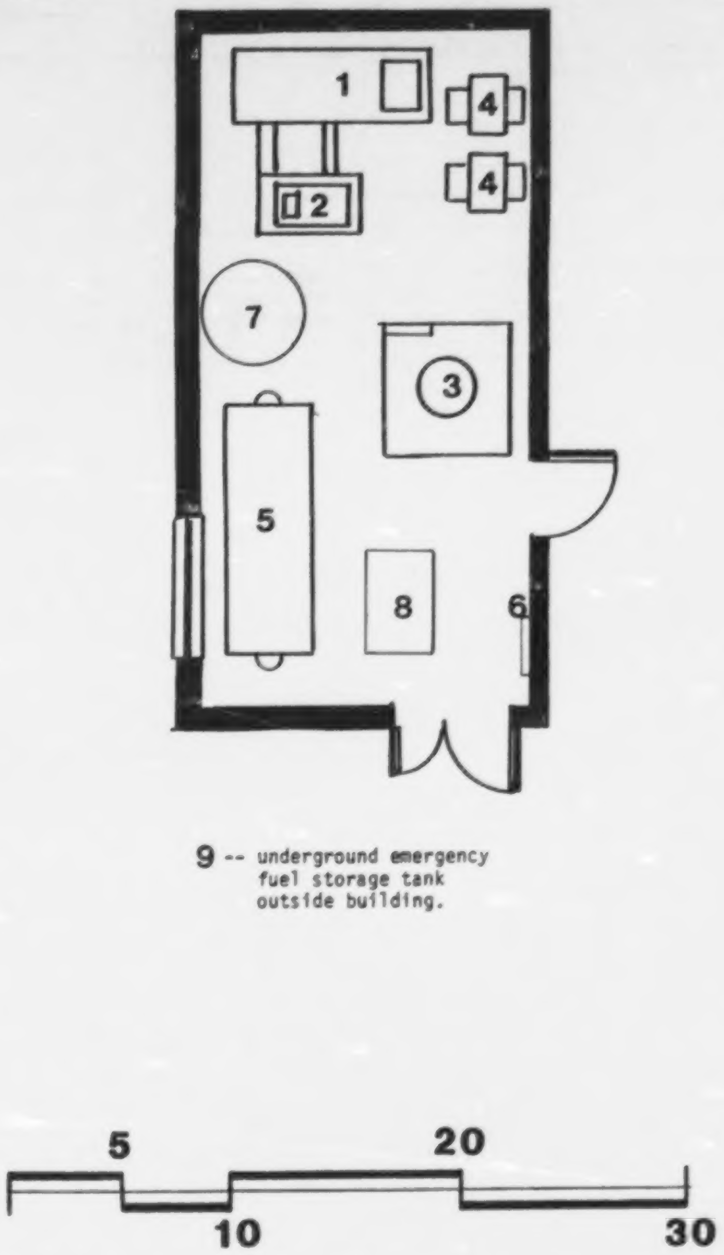
1. Chiller.
2. Condenser.
3. Compressor.
4. Water pumps.
5. Boiler.
6. Electrical switchboard.
7. Emergency water supply tank.
8. Day fuel tank.
9. Emergency fuel storage tank. (Underground--see Vol 2, SB8.)

Note: Alternative energy sources may vary and alter equipment needs. See Vol 2, SB6--AES, for information.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate the mechanical equipment requirements associated with the facility's environmental maintenance.	1. The ratio of mechanical equipment space to the total facility interior floor space varies from 7 percent for small facilities to about 4 percent for large facilities. (See "Issues" box.)	
2. Interior finishes suitable for durability, maintenance, and room function.	2. Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	2. See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation for variable noise levels produced by mechanical equipment.	3. Adjacent room walls should limit sound transmission to 40 decibels.	
4. Information display.	4. The operating instructions, preventive maintenance schedule, wiring and control diagrams, and detailed control sequence should be framed under glass or plastic and posted for easy reference.	
5. Water supply and sanitary sewer.	5. The water supply and sanitary sewer for this facility will be connected to the existing post systems or as prescribed for foreign locations. Provide an emergency water supply tank of 20-gallon per capita capacity for 7 days. Water must be refreshed periodically. See Vol 2, SB8, Survivability Protection.	
6. Adequate lighting.	6. Provide 40-footcandle fluorescent fixtures (ambient).	
7. Thermal comfort.	7. 50 to 68°F range (winter heating), except for batteries, which must be kept at 60 to 68°F.	7. See also Vol 2, SB2--Communication Station Buildings--Mechanical.
8. Electrical power.	8. Commercial electrical service used in the building will be site-specific. Availability depends on the host country if OCONUS. An outdoor transformer can be installed for the mechanical space in terms of general building power. Install 120-volt receptacles as needed. Electrical power must fall within the 10,000- to 500,000-watt range. Frequency levels should be at 50 to 60 hertz ± 5 percent.	8. See also Vol 2, SB2, Communication Station Buildings--Electrical.
9. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	9. Interior enclosure walls--1-hour fire-rated construction. Interior doors--20-minute fire-rated. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	9. See Standardized Modules--Building Design Principles, Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



9 -- underground emergency fuel storage tank outside building.

guidance

1. Storage tank

A single storage tank should be provided for a minimum 15-day supply for both the heating boiler and diesel engine generators. A fiberglass underground tank should be used. A day tank should be provided in the building to supply fuel to both the heating boiler and diesel engine generators. This tank must be equipped with a float switch to activate an alarm indicating a low fuel oil condition.

Doors--The exterior equipment doors should be steel, double swing type with steel frame. The inner opening should be at minimum 6 feet wide by 7 feet high. The equipment door should be equipped with interior locking panic hardware.

Both the exterior personnel and equipment door hinges must be welded to prevent removal of hinge pins if pivots and pins are on the outside.

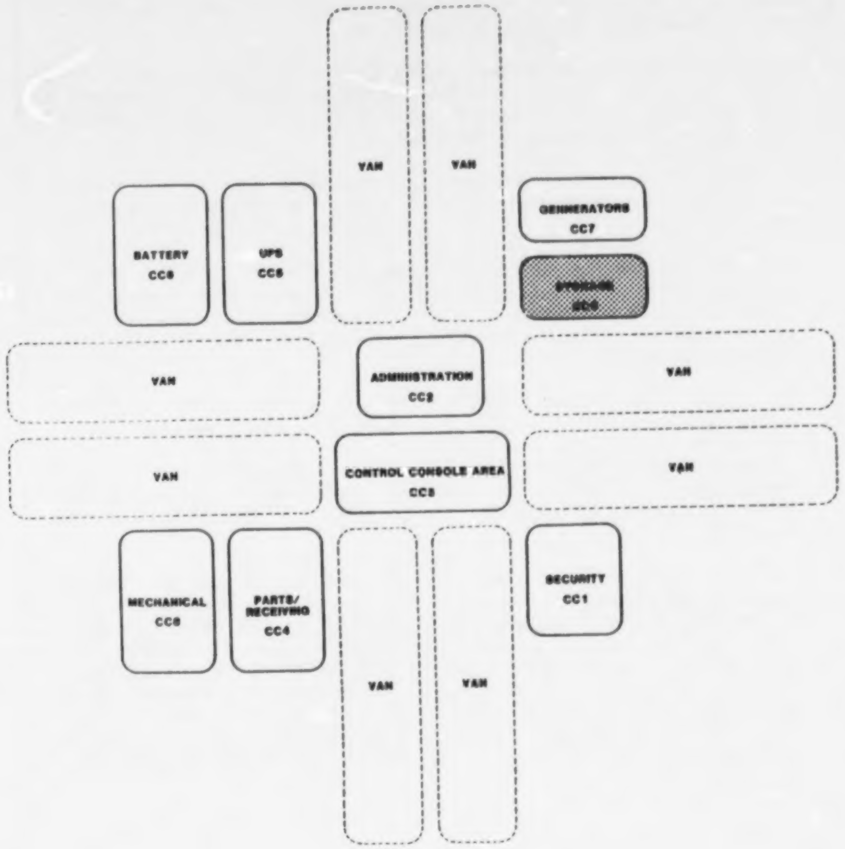
Provide security bars on all openings greater than 7.6 feet at the perimeter and subject to physical intrusion (for example, air intake and exhaust louvers). Their attachment to the structure must be nonremovable from the exterior. See Vol 2, SB7, for additional security guidance.

Structural--The minimum floor design load is 150 pounds per square foot. A clear ceiling height of 10 feet should be provided.

Mechanical equipment should be isolated to minimize vibrations. This can be done by mechanically isolating each individual system on concrete pads separate from the mechanical room floor.

Heat exchangers must be provided with air intake and exhaust ducts to the outside of the building. The size of these ducts means the heat exchangers must be located close to the wall. However, some types of heat exchangers require rear access for maintenance. Location of dehydration pressurization equipment is not critical, but ease of access for maintenance is desirable. Pressure gages should be readily visible to maintenance personnel. Location of the air-conditioning equipment depends on the specific type provided and whether intake and exhaust to the building's outside are required. (2) 5-25

STORAGE CC9


VAN
VAN
GENERATORS
CC7
BATTERY
CC6
UPS
CC5
STORAGE
CC9
VAN
ADMINISTRATION
CC2
VAN
VAN
CONTROL CONSOLE AREA
CC3
VAN
MECHANICAL
CC8
PARTS/
RECEIVING
CC4
SECURITY
CC1
VAN
VAN

function

This area is for the temporary placement of miscellaneous items and nontechnical equipment.

policy/sop

1. All services have physical fitness requirements that must be met. For remote DCS facilities that have no installation services available, it is recommended that exercise equipment be made available. The exacting, sometimes intense, activities of maintaining and controlling the DCS require periodic breaks for physical exercises.

issues and assumptions

1. Storage for exercise equipment

The exercise equipment should not conflict with the function of other personnel-oriented rooms. A general purpose storage room is suitable since the equipment is unofficial.

activities

1. Shelving of miscellaneous sized items.
2. Individual exercise.

personnel

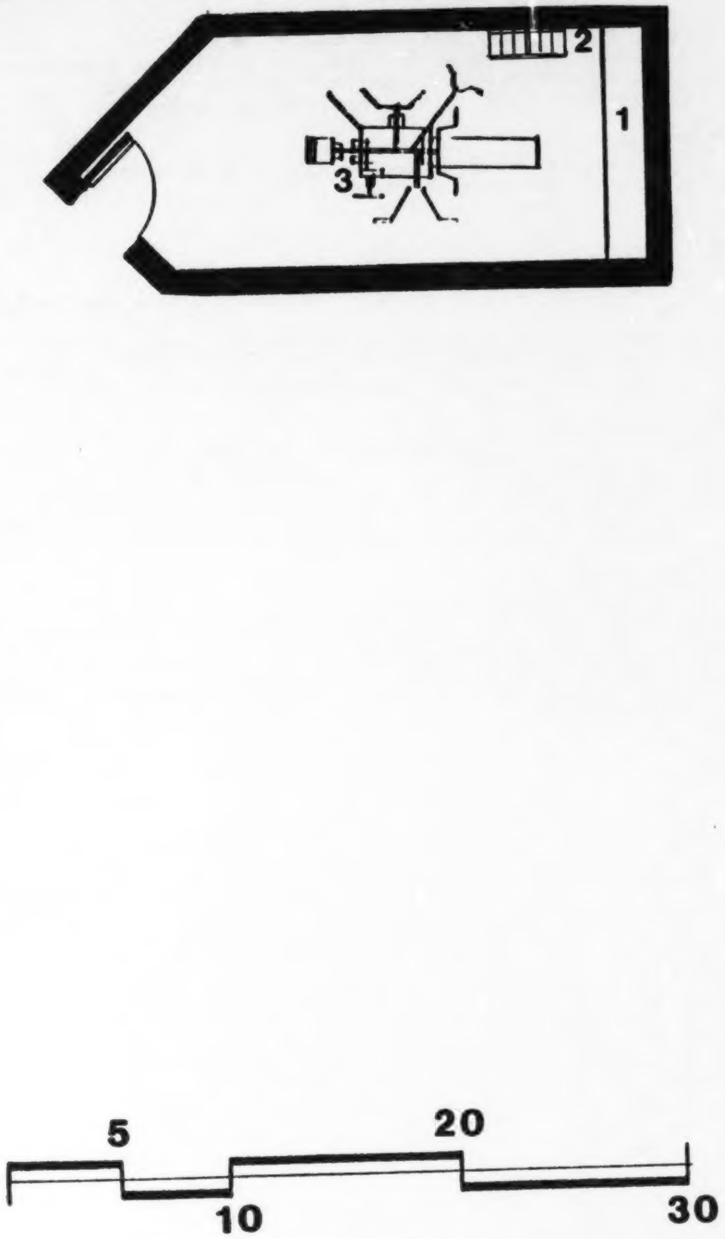
equipment*

1. Shelving 18 inches deep.
2. Small step ladder.
3. Exercycle, universal gym, and/or loose weights.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate two or three persons exercising, plus space to move about for shelving items.	**1.** Allow approximately 250 square feet to accommodate the exercise equipment plus 60 linear feet of shelf space.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation and attenuation for a nondisruptive environment.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Adequate lighting.	**4.** Use 30-footcandle (ambient) fluorescent fixtures.	
5. Thermal comfort.	**5.** Regulate temperature at 68°F (heating), 78°F (cooling). Provide 10 cubic feet per minute per person outside air ventilation rate with on-off switching.	**5.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
6. Electrical power.	**6.** Install 120/208 electrical service. Provide 120-volt outlets--one receptacle for every 10 linear feet of wall. Frequency levels should be at 50 to 60 hertz ± 5 percent.	**6.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
7. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**7.** Interior finish--Class A or B only. Corridor finish--Class A only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**7.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance


2
1
3
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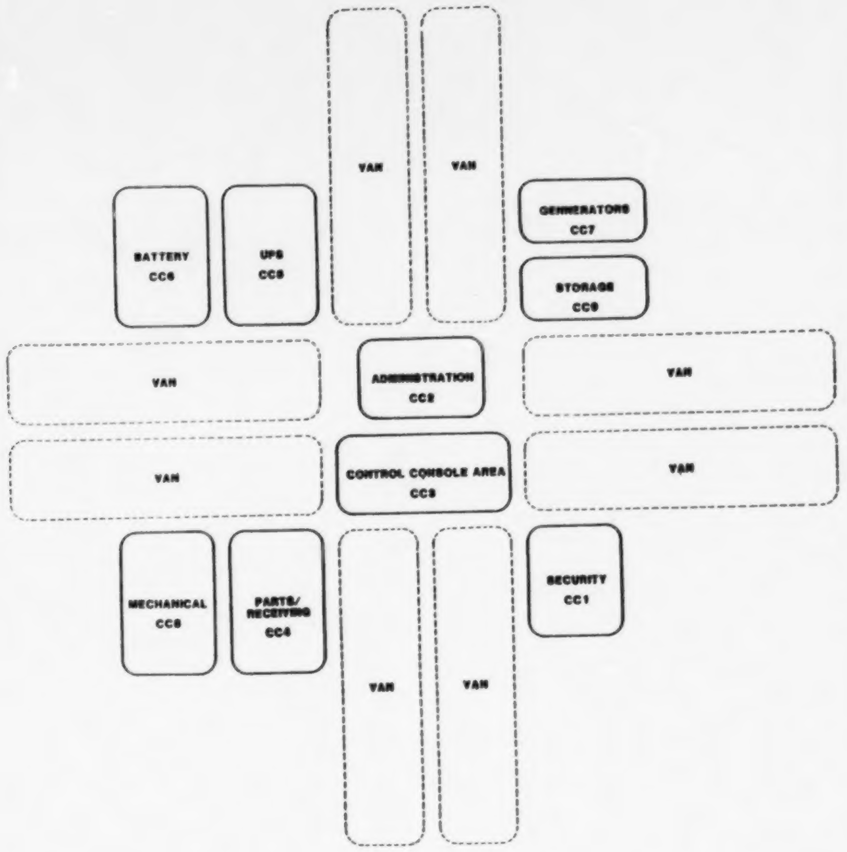
10
30

guidance

STANDARDIZED MODULES CC10


VAN
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BATTERY
CC6
UPS
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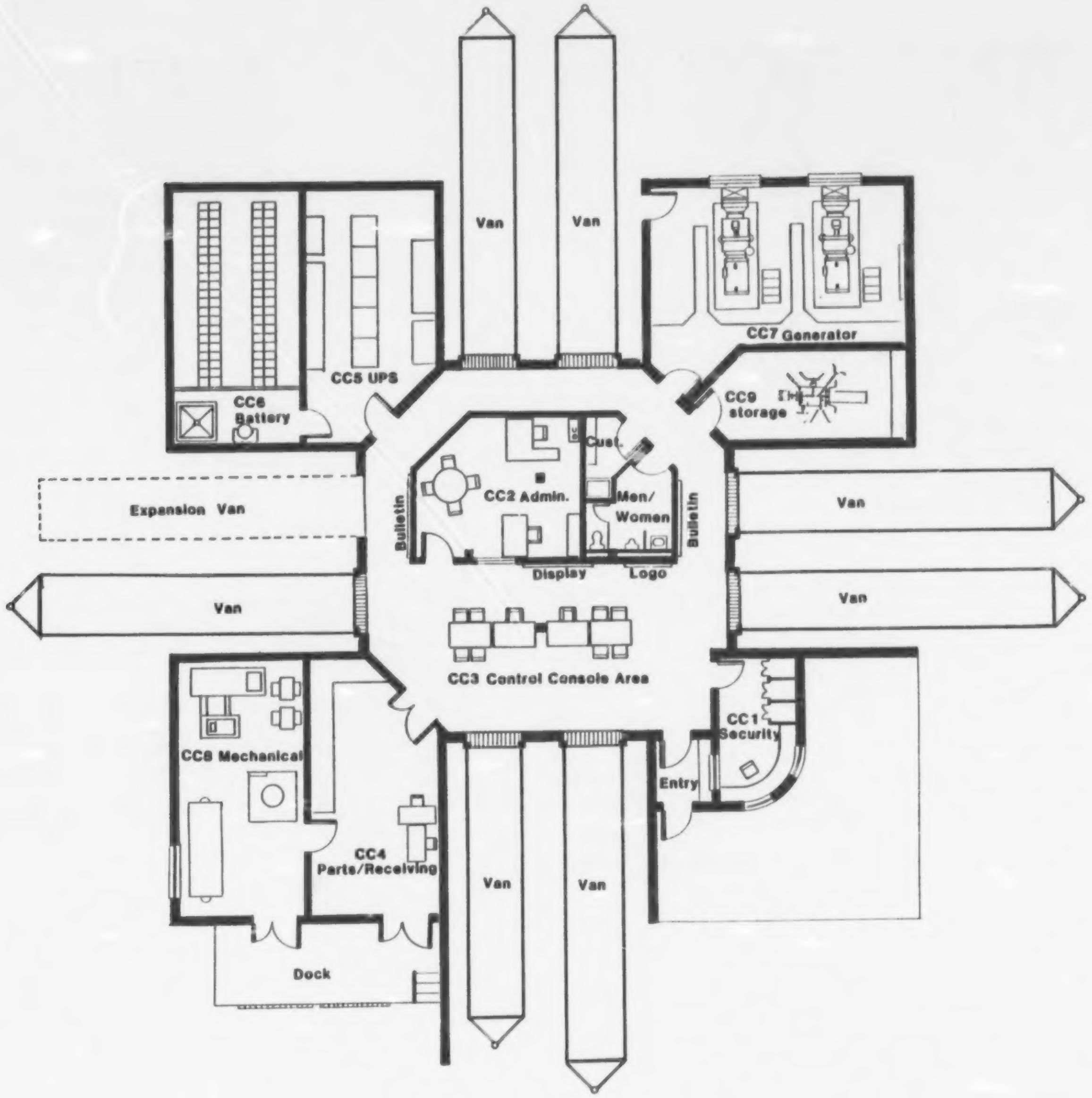
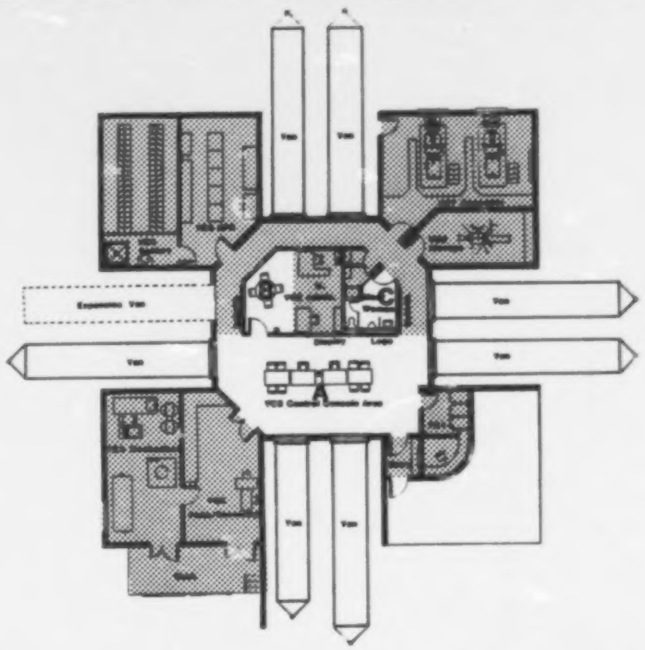
GENERATORS
CC7
STORAGE
CC9
VAN
ADMINISTRATION
CC2
VAN
VAN
CONTROL CONSOLE AREA
CC3
VAN
MECHANICAL
CC8
PARTS/
RECEIVING
CC4
SECURITY
CC1
VAN
VAN

building design principles

1. Efficiency of Operational Functions
   - A. Communication equipment aligned for surveillance and access.
   - B. On-the-job training on equipment which is in operation.
   - C. Accessibility of toilets for operations personnel.
2. Security Operation
   - A. Location of security space to control building access.
   - B. Central monitoring of total site and building security.
   - C. Limited access into secure areas.
3. Integration of Power/UPS Modules
   - A. Economy and efficiency of integrated power modules.
   - B. Minimized impact of generators on communications transmissions.
4. Integration of Parts/Maintenance Modules With Operations
   - A. Parts/maintenance modules located close to operations spaces.
   - B. Loading dock accessibility for equipment and supplies.
5. Fire Protection
   - A. Fire protection classifications: occupancy, hazard of contents, sprinkler protection, and construction/materials.
   - B. Building separation distances.
   - C. Fire protection systems: automatic fire suppression, automatic notification/alarm, and automatic fire detection.
6. Life Safety
   - A. Occupant load determination.
   - B. Protected exits: capacities, number, travel distances, and arrangement of means of egress.
   - C. Allowable interior finishes.
   - D. Egress path identification: illumination, emergency lighting, and marking.


Van
Van
CC5 UPS
CC6 Battery
CC7 Generator
CC9 storage
Cust.
CC2 Admin.
Men/ Women
Bulletin
Bulletin
Expansion Van
Van
Van
Van
Display
Logo
CC3 Control Console Area
CC1 Security
Entry
CC8 Mechanical
CC4 Parts/Receiving
Van
Van
Dock

guidance 1 Efficiency of Operational Functions

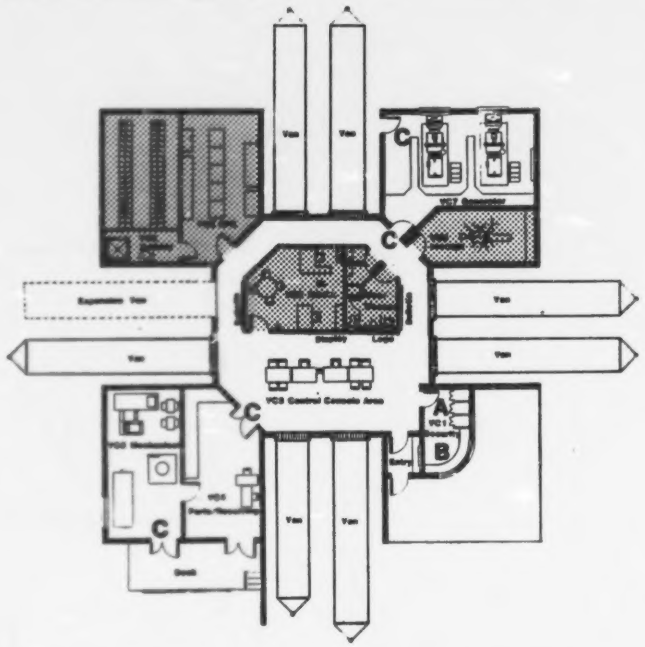

Van
Van
Expansion Van
Van
Van
Van
C
Display
Logs
A
VC3 Control Console Area
Van
Van

A Communication equipment vans should be aligned around the control console area for easy visual surveillance and direct access to all critical equipment. Multiple consoles should be adjacent to each other so that limited personnel can monitor them efficiently from one central location. Tables should be available in the control console area for audiovisual training aids so that personnel can train on the job during regular watch periods.

B To improve the effectiveness of on-the-job training, small groups of four or five can be instructed in a training room for hands-on training work with the communications equipment. Thus, the training room should be close to the operations module.

C Personnel in the control console area should have easy access to toilet facilities.

guidance 2 Security Operation

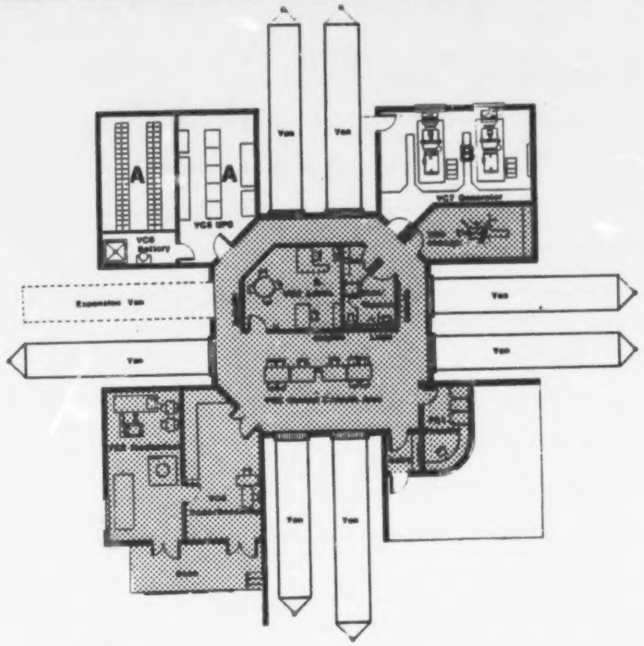

Van
Van
C
VC7 Generator
C
Expansion Van
Van
Van
Van
Display
Logs
VC3 Control Console Area
C
A
VC1
B
Entry
VC4
C
Dock
Van
Van

A The security room is located to provide overview to verify entering visitors. In addition, this room is easily accessible to building occupants for efficient storage and distribution of personnel weapons.

B Security personnel will administer site security, monitor all intrusion detection systems, and initiate appropriate reactions to hostile threats. The security room is therefore designed to provide overview and control over site access and all exterior activities.

C Required doors from other interior modules (or from the outside) that open into secure areas should have opening hardware only on the secure side.

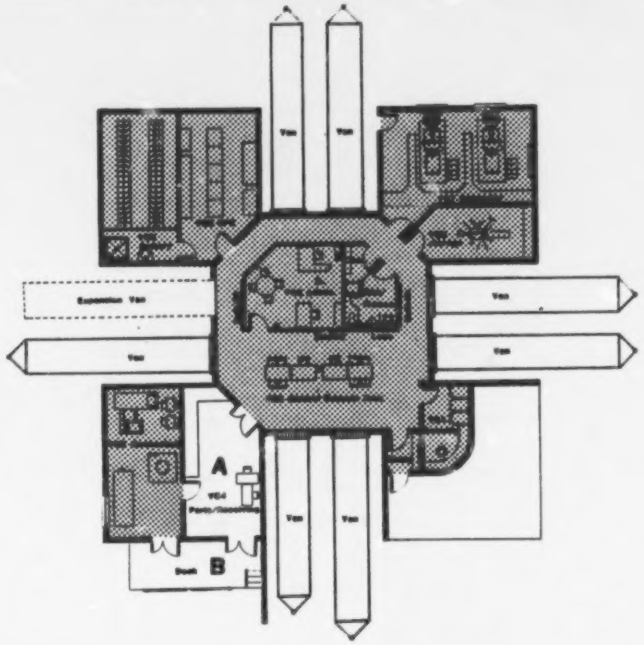
guidance 3 Integration Of Power / UPS Modules


Van
Van
A
A
VC8 UPS
VC8 Battery
B
VC7 Generator
Expansion Van
Van
Van
Van
Van
Van
Dock

A Modules that contain the power and UPS equipment should be close together and well integrated. Direct physical adjacencies will provide economy by minimizing cable lengths and will improve personnel efficiency through interaccess relationships.

B Locating the generator room in a remote area will minimize adverse effects of generator vibrations on communications transmissions.

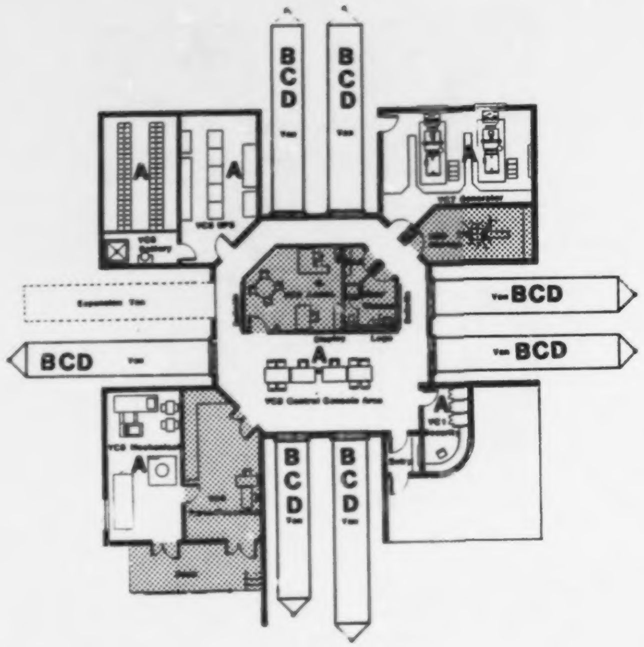
guidance 4 Integration of Parts/Receiving with Operations


Van
Van
Expansion Van
Van
Van
Van
A
VC4
Parts/Receiving
Van
Van
Dock
B

A The parts/receiving room should be well integrated and adjacent to the operations spaces for optimal efficiency and minimal circulation. The secure door between the operations and maintenance/parts spaces is used only as a fire exit and to bring communication equipment in and out via the loading dock. This door should have opening hardware only on the secure side.

B The receiving room must be located within an organizational context such that deliveries for the entire building can be made directly and securely at the loading dock. Large power and communication equipment also can be moved in and out more easily using the loading dock.

guidance 5 Fire Protection



Occupancy classifications: Business (NFPA); B-2 (UBC).

Hazard of contents classification: Ordinary hazard.

Sprinkler protection classification: Ordinary hazard-group 2.

Construction Classification/Materials for Fire Protection (See Vol 2, SB3, Fire Protection/Life Safety)

A All construction elements......... 1-hr rated construction

Type II-N(UBC) for remaining building spaces:

All construction elements......... Noncombustible construction

Building Separation

Site-specific information is required. Comply with Vol 2, SB3, Fire Protection/Life Safety.

Interior Finishes

See Guidance/Life Safety.

Fire Protection Systems

Automatic Fire Suppression

A water sprinkler system shall be provided throughout the facility.

B A Halon 1301 or carbon dioxide system shall be provided under raised floor areas containing nonmetallic sheathed exposed cables when the space underneath is used as an air plenum.

Automatic Notification/Alarm

General alarm activated by the automatic sprinkler system.

C Local alarm to sound in these spaces only, activated by smoke detectors.

Automatic Fire Detection

D Smoke detectors to activate local alarms in these spaces only. In roms that have raised floors, smoke detectors shall be located under the raised floor.

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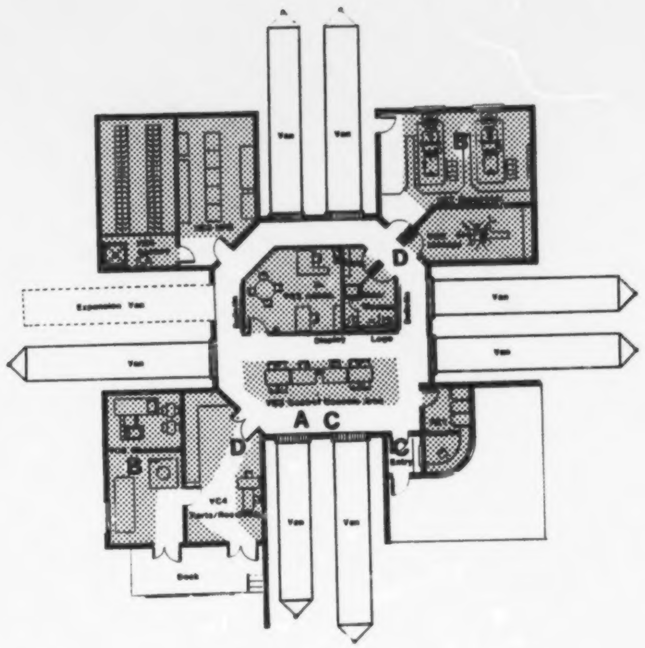
*See Vol 2, SB7, Security for vault construction requirements that may be more stringent than those imposed by fire protection requirements.

guidance 6 Life Safety



Exit capacities

Corridors--100 persons per unit of exit width for travel in either direction. The minimum width of any exit access corridor or passageway shall be 44 inches in the clear.

Doors--100 persons per unit of exit width (a 3-foot door provides 1.5 units of exit width, providing an exit capacity for 150 persons).

Number of exits

No less than two exits shall be accessible from every part of every floor. One exit is permitted when the room or area has: (1) a total occupant load of less than 100 persons, (2) direct exit to an open area outside the building at the ground level, and (3) a total travel distance on the same level of not over 100 feet. (If stairs are involved, they shall be no more than 15 feet in height and shall be provided with complete enclosures to separate the stairs from any other part of the building.)

Exit travel distances

Required exits shall be located to allow access without passage through areas that may be locked. No dead end corridor shall exceed 50 feet. Travel distance to exits shall be no more than 300 feet when the building is protected throughout by an approved automatic sprinkler system.

Arrangement of means of egress

Exit access and travel routes to exits are shown in the plan.

A Exit doors in vaulted areas that contain communications equipment are secured and permit egress out only. Exit access routes through vaulted areas from spaces outside the vaulted area are not permitted for security reasons.

B Two means of egress shall be provided from higher hazard areas, including mechanical and generator spaces. Exit access from any other space may not pass through the mechanical or generator spaces (see exit marking). For security, when mechanical or generator spaces have exit access routes through interior spaces, exit access doors from these spaces, when opened, shall sound an alarm and transmit a signal to the annunciator panel in the security space. Access for normal maintenance in mechanical and generator spaces shall be through the exterior doors.

guidance

Interior finishes

C Interior finish in exit access corridors shall be Class A only.

Interior finish in the remainder of the building shall be Class A or B only.

Means of egress lighting

Exits and exit access, including stairs, aisles, corridors, and passageways leading to an exit, shall be lighted continuously during times when the conditions of occupancy require means of egress to be available. Lighting should be no less than 1 footcandle measured at the floor.

Emergency lighting

Emergency lighting shall be provided in windowless buildings for designated aisles, corridors, and passageways leading to an exit. Emergency lighting shall stay at least 1 footcandle throughout the means of egress for 1.5 hours in the event of normal lighting failure.

Marking the means of egress

Exits shall be marked by an approved sign readily visible from any direction of exit access. Signs shall be placed such that no point in the exit access is more than 100 feet from the nearest visible sign.

D Doors located or arranged so that they are likely to be mistaken for exits shall be identified by a sign reading "NOT AN EXIT."

guidance

RS-1

DCA CIRCULAR 300-95-1

US Army Corps
of Engineers
Construction Engineering
Research Laboratory

NOVEMBER
1984

U.S. Army Construction Engineering Research Laboratory

SEMIHARDENED CONTINGENCY COMMUNICATION SHELTERS

Prepared for the

Defense Communications Agency
Defense Communications Engineering Center
1860 Wiehle Avenue
Reston, Virginia 22090

Under
MIPR HC1001-3-40111

FOREWORD

This investigation was performed by the Facility Systems Division (FS), U.S. Army Construction Engineering Research Laboratory (USA-CERL), for the Defense Communication Agency under Order No. HC1001-3-40111 (DEC. 1982).

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SECTION A INTRODUCTION

A INTRODUCTION

Purpose

The purpose of this analysis is to (1) investigate concepts that can be used in constructing semihardened shelters for Defense Communications Systems (DCS) prepositioned equipment or operations functions, (2) provide planners with parametric relationships that will simplify selection of the least expensive facility for any given location, threat, and function, and (3) present one case study applying the concepts found to be least costly to an AUTODIN Switch Facility.

Background

When examining wartime DCS facilities' performance requirements and solution options, a discrepancy in construction cost and level of protection provided is apparent between the present peacetime structures and those fully hardened redoubts capable of surviving direct hits by the heaviest conventional weapons. There is a need to resolve this discrepancy with an inventory of facility concepts using several construction techniques that provide a range of protection levels at minimized construction cost. Recent attention given to identifying storage facilities for contingency or reconstitution assets therefore has emphasized the need for facility concepts that can relate construction cost directly with the level of protection achieved.

Two competing schools of thought on DCS survivability both paradoxically support the development of such a concept. The first presupposes destruction of most DCS fixed assets at the outset of hostilities, thus placing the burden of command and control (CAC) communications responsibility on transportable equipment prepositioned in trucks, trailers, or vans. The second school takes a more optimistic perspective, suggesting that cost-effective steps can be taken to enhance the survivability of fixed sites so that a large percentage could remain operational at some level. For the damage inevitably experienced, prepositioned reconstitution packages are proposed to permit restoration of critical links and service.

Without attempting to resolve this difference in viewpoint, it should nevertheless be clear that the case for transportable communications units logically requires a storage plan which would provide much greater survivability than the vulnerable stations which the transportables are designed to replace. Basing the transportable units in an open motor pool or conventional warehouse sharply lowers the probability that a significant number will remain unscathed and ready for use soon after attack. The only reasonable alternative would be greater dispersion, but the need for physical security, logistic support, and long-term environmental protection makes this option less attractive for the DCS.

Similarly, the proponents of upgrading existing stations need a low-cost hardened shelter to store reconstitution packages. Warehouses and other bulk storage facilities are as unsuitable for this purpose as they are for transportable units, and for the same reason. Therefore, some tradeoffs need to be investigated between space for reconstitution package storage and that for actual operations, along with the possibility of reducing the quantity and cost of reconstitutional assets at certain locations. Given the need for a low-cost, reasonably hardened shelter capable of enduring moderate blast and overpressure threats, a combination of construction techniques and support equipment configurations appears to offer the best potential solution.

The desired performance attributes for the proposed facility are:

1. Low first cost--no greater than 1.5 times equivalent nonhardened communication facility construction cost.

2. Rapid construction--no greater than 80 percent equivalent nonhardened construction time.

3. Endurability--capable of sustaining direct hits by heavy armor/concrete piercing ground weapons and near misses by 1.1-ton aerial ordnance without loss of structural integrity or major damage to personnel and equipment located inside.

4. Low operating cost--energy and maintenance cost no greater than 80 percent equivalent nonhardened construction.

Threat Definition

The major concern in developing semihardened shelters for Defense Communications Agency (DCA) equipment and personnel is to protect the stored contents against external attacks from the enemy. During these attacks, the shelters would need to sustain direct hits from heavy armor/concrete piercing ground weapons and near misses by 1.1-ton aerial ordnance without loss of structural integrity or major damage to personnel and equipment inside. To develop the best type of shelter, this study analyzed each threat separately and quantitatively. (The threat for the AUTODIN Switch Facility was limited to aerial ordnance falling no closer than 75 ft from the facility.) The analysis of these primary threats is summarized below.

1. Heavy armor/concrete piercing projectiles. These projectiles are very effective in perforating armor plate and reinforced concrete. The projectiles have a tough hardened alloy nose to withstand the high impact stresses and to distribute them over the projectile's forward body. Projectiles typically are fused with delayed action inertia-type base fuses that detonate the explosives after maximum penetration has been achieved. Approximately 15 percent of the projectile weight is highly explosive. Oblique impact decreases penetration and causes the projectiles to ricochet. Based on the available data, the Soviet 8.02-in. concrete penetrating artillery round weighing about 220.7 lb and containing about 34.2 lb of TNT was selected by DCA as the most logical threat. Rocket-assisted projectiles are believed to be under development for some of the artillery weapons which would greatly extend these weapons' velocity and range capabilities; however, they were not considered in this analysis.

2. Aerial ordnance. There are several types of highly explosive (HE) bombs such as general purpose, light case, armor piercing, semiarmor piercing, and fragmentation. General purpose (GP) bombs are designed for general destruction by blast and fragmentation. They will perforate light reinforced concrete and thin armor. After penetrating the earth, they will cause considerable damage to nearby structures due to the confined explosion. Light case (LC) bombs contain a larger percentage of HE and, consequently, their cases readily deform upon striking resistant materials; their main damage results from blast. Armor piercing (AP) bombs have heavy cases that resist deformation when striking heavily protected targets such as protective structures. Semiarmor-piercing (SAP) bombs have characteristics similar to AP bombs; however, they are not as effective. The charge weight ratios for HE bombs are approximately as follows: GP 50 percent; LC 75 to 80 percent; AP 5 to 15 percent; and SAP 30 percent. Fragmentation bombs contain only enough explosives to fracture their case and cause maximum velocity of the fragments. The 1.1-ton GP bomb was selected as the most logical threat and it was assumed to contain 1103 lb of TNT.

Approach

The rest of this report is organized into five sections that describe the development process and the case study.

Section B describes the basic requirements and initial conceptual designs for the Transportable Unit Storage Shelter, the Reconstitutional Package Storage Shelter, and the Operational Shelter. While developing this section, design alternatives were considered, evaluated, and selected for use in the conceptual design and cost estimate. Rectangular cross section structures of cast-in-place concrete were selected as baseline design.

Section C describes baseline buildings using a preengineered metal structure as the unhardened example and a standard ammunition igloo for the semihardened example. The concepts were developed to provide a comparative basis for addressing a "low first cost" criteria. Neither building could meet the threat definition nor could they be modified easily to provide the needed hardness. The igloo would provide a low level of protection, however, and could be considered for use in some areas. Buildings can be constructed at grade and mounded, partially buried and mounded, or totally buried. The totally buried building was used in the comparative analysis.

Section D addresses several construction alternatives, each designed to reduce the onsite construction time or the skilled labor demands. Two alternatives specifically discussed for the operational shelter would have limited usefulness for storing truck-mounted equipment. The quality of space provided also varies among the alternatives, which may be a consideration in the final selection of building configuration and construction technique.

Section E presents general explanations of the design method and construction cost estimates together with the major underlying assumptions. The important findings of the design and cost estimating aspects of this investigation are summarized. Also summarized are alternative construction concepts that satisfy the specified performance criteria for the various shelter types. The planner is completely responsible for selecting the most suitable shelter concept and construction technique at a specific geographical location.

In Section F, the least-cost alternatives developed in Sections D and E are applied to an AUTODIN Switch Facility with a limited threat definition and different operational requirements. Facility configurations and cost estimates are presented.

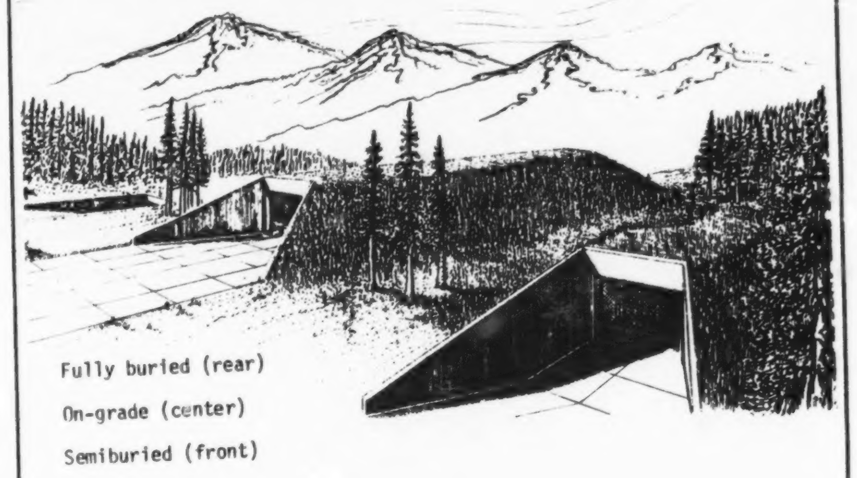


FIGURE A-1. GENERAL APPEARANCE OF SHELTERS.

SECTION B BASIC DESIGN

B1
RECONFIGURATION STORAGE SHELTER

function

To store truck-transportable DCS communication units in a way that enables them to survive attack and be available for reestablishing the communication network after the complete loss of unhardened communication facilities.

policy/sop

1. DCS has prepositioned communication equipment in Europe for reestablishing its communications network after initiation of hostilities and loss of existing unhardened facilities. Facilities are needed to provide a level of protection to the equipment greater than that provided in the motor pools, warehouses, and aircraft hangars.
2. No provisions will be made in the shelter for housing personnel. During an attack, if personnel should be present, space around the vehicles could be used for shelter; but life support systems and facilities are not required.
3. Site security will be external to the shelter and will be installed and monitored by others (i.e., personnel other than those responsible for building operation).
4. The communication equipment will not be operated in the shelter during or after the attack. There is no secondary mission for the shelter after the vehicles have been removed.
5. Systems should be provided by others to monitor and manage equipment in the shelter from a remote location.
6. If needed, unprotected power generation equipment can be provided to back up the base power supply. However, exposed components should be considered sacrificed during the attack and unusable afterwards. Power must be provided for opening the blast doors.
7. No effort will be made to camouflage the shelters' location.

issues and assumptions

1. Siting

Shelters should be located away from primary targets (e.g., aircraft, runways, weapon systems, ammunition dumps) to reduce the possibility of collateral damage from the attack. It has been assumed that the shelters are not prime targets and will be subjected only to warheads intended for other targets. Shelters may be located on- or off-post as needed to provide adequate separation from prime targets. If located off-post, the cost of providing and maintaining security must be considered in planning.

Shelter concealment has not been considered because (1) construction can be observed easily by satellite, and (2) the large, paved area needed for maneuvering vehicles in front of the shelter is highly visible.

Depending on the terrain, the shelter can be constructed either on the surface and mounded, partially buried and mounded, or totally buried. If possible, it should be sited to provide an entrance that slopes away from the shelter. This sloping entrance would help keep debris from accumulating on the entrance pavement, maintaining a clear area for when the equipment must be removed and put into operation. Advantage should be taken of the land's natural contour. Foundation drainage is required in most configurations to control groundwater. Use of tunnels in mountainous areas should be considered.

2. Access

Transport cabs and trailers can be backed into one long garage or side-by-side into two garages. Also, vehicles can be stored using either a "drive-through" configuration or an alternative single-access drive that would require backing-in for storage. Rapid mobilization requires that all vehicles be headed-out while in storage. The drive-through configuration may simplify the vehicles' movement and eliminate the need for backing into the long shelter. However, the drive-through configuration would require a second vehicular entrance into the shelter complete with a large blast door, extended roofline to protect the door, and entrance pad with a roadway connecting it to the other entrance. The one long shelter configuration was selected for this comparative analysis as being the most cost-effective (Figures B1-1 and B1-2).

Equipment shelter floors will be sloped to drain and constructed with depressed wheel tracks for guiding trailers as they are backed into the shelter. Cover plates will be provided to cover the tracks in the front section of the shelter to simplify movement of personnel and the portable generators (Figures B1-3 through B1-5).

issues and assumptions

3. Primary mechanical systems and the need for emergency power

Each shelter shall have environmental control equipment. Base electrical power will be the shelter's main power source. Emergency and back-up power will be provided by a portable generator using an external connector. Power requirements are limited to maintaining the environment, opening the blast doors, and providing minimal lighting after attack. One portable generator could serve several shelters located on an installation. The stored equipment is relatively insensitive to temperature changes; moreover, since the shelter will be earth-covered, it should experience very little temperature change from the weather. For these reasons, the stored equipment would not be damaged if the power supply were interrupted over an extended period.

4. Security

It has been assumed that project planners will satisfy security requirements and, thus, such information has not been included in this comparative analysis.

activities

1. Driving in equipment initially.
2. Making the equipment accessible for periodic maintenance.
3. Monitoring humidity and temperature.
4. Maintaining and installing accessories.

personnel

1. Equipment maintenance team.
2. Inventory personnel.
3. Vehicle drivers.

equipment

1. Simple HVAC unit with heating and dehumidification capability.
2. Separate control for ventilation air.
3. Humidity and temperature instruments.
4. Portable electronic testing equipment on movable carts.

requirements	criteria	commentary
1. Adequate space.	1. Shelter must be sized to house the truck-mounted equipment and to provide adequate clearance for moving the truck in and out of the shelter. Space must be provided around the vehicles to allow maintenance personnel access to the equipment.	
2. Structure.	2. The shelter should be semihardened to withstand direct hits from at least two HE artillery rounds and near misses of bombs described under Threat definition (Section A in this document). These warheads would be falling outside their primary targets and would come near the communications shelter by accident.	
3. Openings.	3. One large vehicular blast door on a hanger-type sliding unit and a separate personnel-size sliding blast door must be provided. The personnel door would provide access to the equipment without opening the large (main) blast door.	
4. Ventilation system and humidity control.	4. A filter must be provided to remove dust from air in the shelter. Relative humidity control: 95 to 100 percent noncondensing at an ambient temperature of 100 degrees F.	
5. Illumination.	5. A 50-lux general light level must be provided with 110-V outlets for adjustable lights (for parts installation and/or inventory).	
6. Power.	6. A 110-V a.c. source must be provided for maintenance tools, 20 ft on-center throughout the shelter.	
7. Heating.	7. Shelter temperature must be maintainable at a level that will make it easy to start the truck. (The stored equipment can withstand temperatures of -50 to 155 degrees F without damage.)	
8. Survivability protection.	8. High-altitude electromagnetic pulse (HEMP) and chemical-biological-radiological (CBR) control equipment must be installed.	
9. Security fence.	9. An 8-ft-high chain-link fence with three strands of barbed wire, as a minimum, will be provided by others.	
10. Drainage ditches.	10. Cross-overs for drainage ditches must be provided so that all areas are readily accessible.	
11. Pavements.	11. Pavements and other site elements must be laid out to provide for the turning radius (35 ft) of the vehicle(s) stored.	

guidance

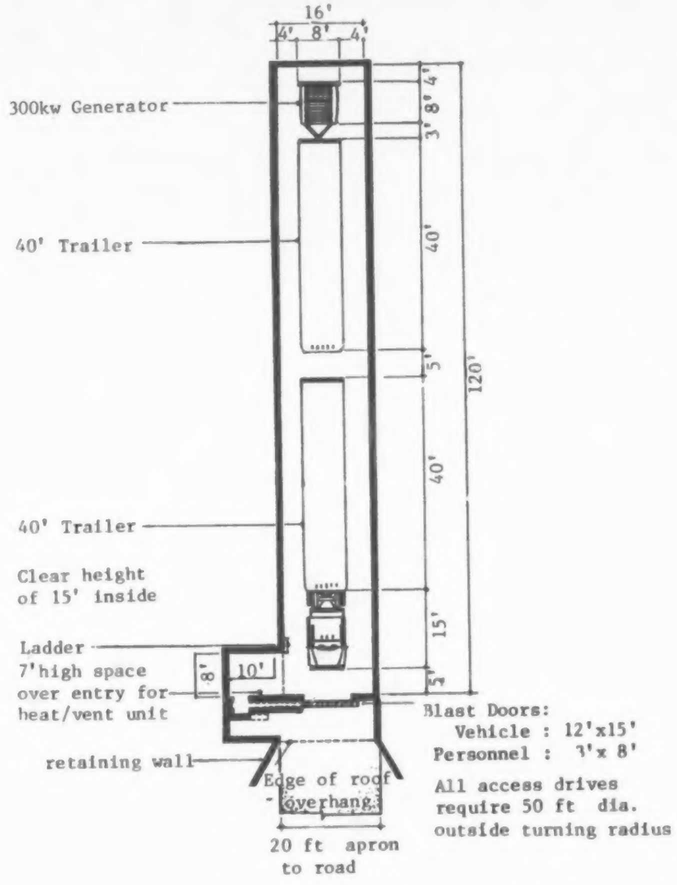

16'
4'
8'
4'
300kw Generator
4'
8'
3'
40' Trailer
40'
5'
120'
40'
40' Trailer
Clear height
of 15' inside
15'
5'
Ladder
7'high space
over entry for
heat/vent unit
8'
10'
Blast Doors:
Vehicle : 12'x15'
Personnel : 3'x 8'
retaining wall
Edge of roof
overhang
All access drives
require 50 ft dia.
outside turning radius
20 ft apron
to road

FIGURE B1-1. FLOOR PLAN--TRANSPORTABLE UNIT STORAGE SHELTER.

guidance

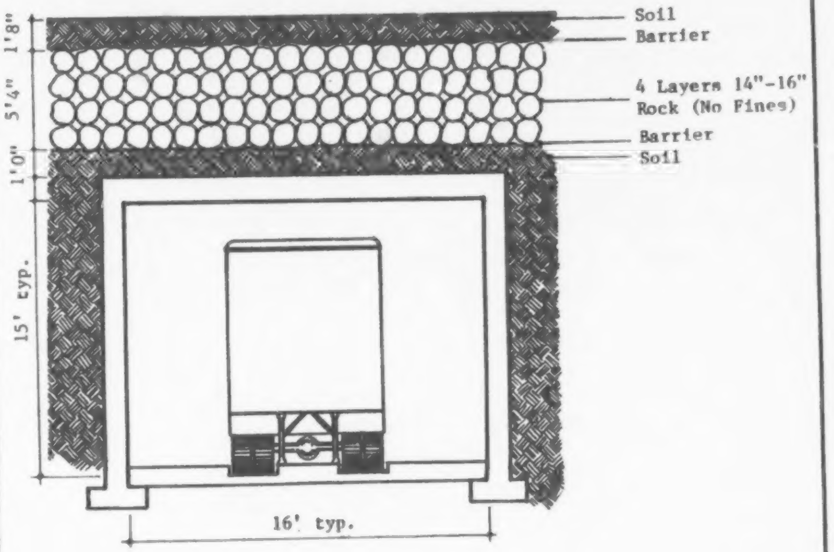
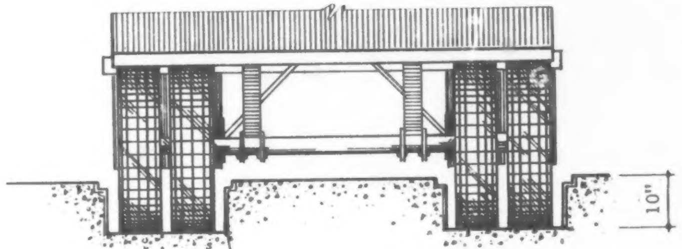

1'8"
5'4"
1'0"
15' typ.
Soil
Barrier
4 Layers 14"-16"
Rock (No Fines)
Barrier
Soil
16' typ.

FIGURE B1-2. SHELTER SECTION.

guidance



Steel sides provide form for concrete and prevent tire damage.

FIGURE B1-3. FLOOR TRACK SECTION.

Steel cover over track provides continuous surface for transport of generators and equipment.

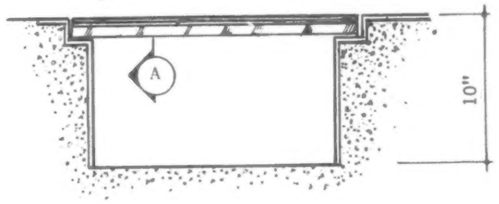


FIGURE B1-4. FlOOR TRACK DETAIL.

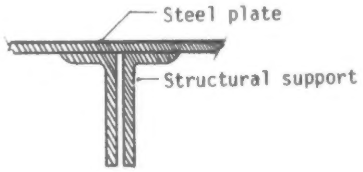


FIGURE B1-5. SECTION THROUGH TRACK COVER.

systems

1. Environmental control system

Storage shelter requirements affect the environmental control system in two ways. First, the exterior environment's influence on the interior is narrowed through the insulating effect of the earth cover. Second, limited activities are expected to be performed in the conditioned space. The primary load is assumed to be dehumidification in connection with storage.

2. Power systems

Commercial power will be used during the preattack period. There are no power requirements other than for battery-powered lighting during the attack period. To lower construction and operating costs, it was decided not to include a dedicated power generator in the shelter. In the post-attack period, a portable generator will supply power through an external connector to open the blast doors for vehicle removal.

B2 RECONSTITUTION STORAGE SHELTER

function

To store vehicle-mounted DCS communication equipment such that it will be protected from attack and accessible for reconstituting damaged communication centers to reestablish the network.

policy/sop

1. DCS has prepositioned communication equipment in Europe for use in reestablishing its communications network after initiation of hostilities and loss of existing unhardened facilities. Facilities are needed to provide a level of protection to the equipment greater than that provided in the motor pools, warehouses, and aircraft hangars.
2. No provisions will be made for housing personnel in the shelter. During an attack, if personnel should be present, space around the vehicles could be used for shelter, but life support systems and facilities are not required.
3. Site security will be external to the shelter and installed/monitored by others.
4. The communication equipment will not be operated in the shelter during or after the attack. The shelter has no secondary mission after the vehicles have been removed.
5. Systems should be provided by others to remotely monitor and manage the equipment installed in the shelter.
6. If needed, unprotected power generation equipment can be provided as a backup to base power. However, exposed components should be considered sacrificed during the attack and unusable afterwards. Power must be provided for opening the blast doors.

issues and assumptions

1. Siting

Shelters should be located away from primary targets (i.e., aircraft, runways, weapon systems, ammunition dumps) to reduce the possibility of collateral damage from attack. It has been assumed that the shelters are not prime targets and will be subjected only to warheads intended for other targets. Shelters may be located on- or off-post as needed to provide adequate separation from prime targets. If located off-post, the cost of providing and maintaining security must be considered in planning.

Shelter concealment has not been considered because (1) construction can be observed easily by satellite, and (2) the large paved area needed for maneuvering vehicles in front of the shelter is highly visible.

Depending on the terrain, the shelter can be constructed either on the surface and mounded, partially buried and mounded, or totally buried. If possible, the shelter should be sited to provide an entrance that slopes away from the shelter. This sloping entrance would help keep debris from accumulating on the entrance pavement, maintaining a clear area for when the equipment must be removed and put into operation. Advantage should be taken of the land's natural contour. Foundation drainage also is required in most configurations to control groundwater. Consideration should be given to using tunnels in mountainous areas.

2. Access

Trucks and trailers will be backed into the shelter. A "drive-through" configuration may simplify the vehicles' movement and eliminate the need for backing into the shelter. However, the drive-through configuration would require a second vehicular entrance into the shelter complete with a large blast door, extended roof to protect the door, and entrance pad with a roadway connecting it to the other entrance. The single-entrance configuration was selected for this comparative analysis as being the most cost-effective (Figure B2-1).

The shelter floor will be sloped to drain and constructed with depressed wheel tracks for guiding the truck as it backs into the shelter. Cover plates will be provided to cover the tracks in the front section of the shelter to simplify personnel movement.

3. Primary mechanical systems and the need for emergency power

Each shelter shall have environmental control equipment. Base electrical power will be the shelter's main power source. Emergency and back-up power will be provided by a portable generator using an external connector. Power requirements are limited to maintaining the environment, opening the blast doors, and providing minimal lighting after the attack. One portable generator could serve several shelters located on an installation. The stored equipment is relatively insensitive to temperature changes. Moreover, since the shelter will be earth covered, it should experience very little temperature change from weather. For these reasons, the stored equipment would not be damaged if the power supply were interrupted over an extended period.

issues and assumptions

4. Security

It has been assumed that project planners will satisfy security requirements and, thus, this information has not been included here.

activities

1. Driving in equipment initially.
2. Making the equipment accessible for periodic maintenance.
3. Monitoring humidity and temperature.
4. Installing and maintaining accessories.

personnel

1. Equipment maintenance team.
2. Inventory personnel.
3. Vehicle drivers.

equipment

1. Simple HVAC unit with heating and dehumidification capability.
2. Separate control of ventilation air.
3. Humidity and temperature instruments.
4. Portable electronic testing equipment on movable carts.

READEX FICHE

requirements	criteria	commentary
1. Adequate space.	1. Shelter must be sized to house the truck-mounted equipment and to provide adequate clearance for moving around the vehicle to allow maintenance personnel access to the equipment.	
2. Structure.	2. Shelter should be semi-hardened to withstand direct hits from at least two HE artillery rounds and near misses of bombs described under Threat definition. These warheads would be falling outside their primary targets and come near the communications shelter only by accident.	
3. Openings.	3. One large vehicular blast door on a hanger-type sliding unit and a separate personnel-size sliding blast door must be provided. The personnel door will provide access to the equipment without opening the large (main) blast door.	
4. Ventilation system and humidity control.	4. A filter must be installed to remove dust from the air in the shelter. Relative humidity control should maintain a 95 to 100 percent noncondensing environment at an ambient temperature of 100 degrees F.	
5. Illumination.	5. A 50-lux general light level must be provided with 110-V a.c. outlets for adjustable lights (for parts installation and/or inventory).	
6. Power.	6. Supply 110-V a.c. power for maintenance tools, 20 ft on-center throughout the shelter.	
7. Heating.	7. Shelter temperature must be maintained at a level that will make it easy to start the truck. (Stored equipment can withstand temperatures of -50 to 155 degrees F without damage.)	
8. Survivability.	8. HEMP and CBR control equipment must be installed.	
9. Security fence.	9. An 8-ft-high, chain-link fence with three strands of barbed wire, as a minimum, will be provided by others.	
10. Drainage ditches.	10. Cross-overs for drainage ditches must be provided so that all areas are readily accessible.	
11. Pavements.	11. Pavements and other site elements must be laid out to provide for the turning radius (35 ft) of the stored vehicle.	

guidance

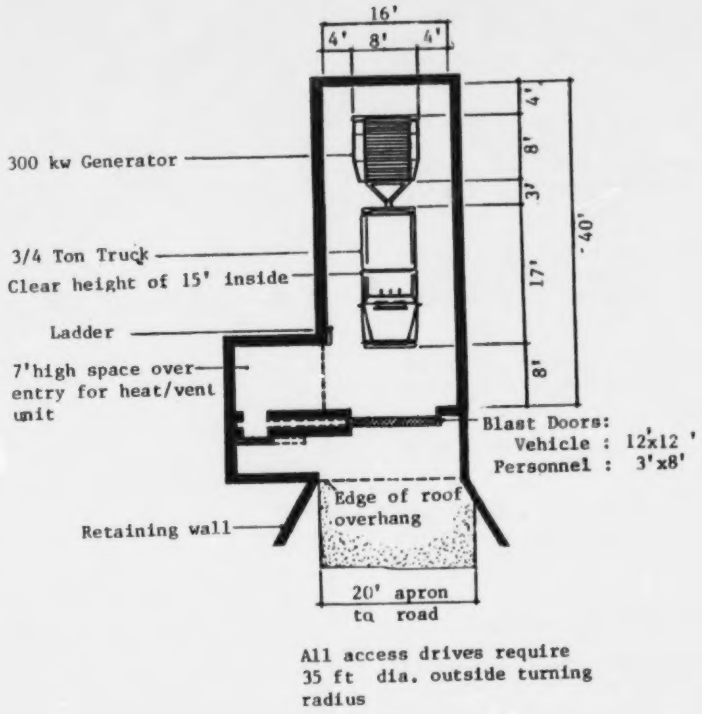

16'
4'
8'
4'
4'
8'
3'
17'
8'
40'
300 kw Generator
3/4 Ton Truck
Clear height of 15' inside
Ladder
7'high space over-entry for heat/vent unit
Blast Doors:
Vehicle : 12'x12 '
Personnel : 3'x8'
Edge of roof overhang
Retaining wall
20' apron to road
All access drives require 35 ft dia. outside turning radius

FIGURE B2-1. FLOOOR PLAN--RECONSTITUTIONAL PACKAGE STORAGE SHELTER.

systems

1. Environmental control system

Storage shelter requirements affect the environmental control system in two ways. First, the exterior environment's influence on the interior is narrowed through the insulating effect of the earth cover. Second, the conditioned space is expected to support only limited activities. The primary load is assumed to be dehumidification in connection with storage.

2. Power systems

Commercial power will be used during the preattack period. The shelter has no power requirements, other than for battery-powered lighting, during the attack period. To lower construction and operation costs, it was decided not to include a dedicated power generator in the shelter. In the postattack period, a portable generator will supply power through an external connector to open the blast doors for vehicle removal.

B3 DCS OPERATIONAL SHELTER

function

To provide a semihardened communications operational center that can be used to reestablish and operate the DCS communications network in areas subject to attack.

policy/sop

1. The operational shelter will be used either in conjunction with a Transportable Unit Shelter or in a stand-alone configuration.
2. Space will be provided for a crew of 25 plus sanitary facilities, water supply, and power supply to support operations during base power interruptions.
3. Site security will be external to the facility and installed/monitored by others.
4. Provisions will be made for maintaining an environment that would support life in the operational space for at least 4 hours without external assistance.
5. This comparative analysis does not consider the design, siting, and construction of an antenna.
6. The shelter should provide for the command and communication circuits from the unhardened communication center as well as circuits to an antenna located at some remote site.
7. The base power supply will be the shelter's primary source. An onsite power supply will be provided for postattack operations.

activities

1. Establishing workstations.
2. Installing communication equipment initially, including integration and checkout.
3. Filling water and fuel storage tanks.
4. Checking backup power.
5. Testing environmental control equipment.
6. Monitoring internal environment and status of storage tanks.
7. Performing periodic operational checks.
8. Maintaining equipment.

personnel

1. Equipment installers.
2. DEH personnel to fill and maintain storage tanks.
3. Inventory personnel.
4. Equipment test, operation, and evaluation personnel.
5. DEH building equipment maintenance personnel.

equipment

1. Heating, ventilating, and A/C equipment.
2. Temperature and humidity sensors and controls.
3. Communication equipment.
4. Portable electronic testing equipment on movable carts.
5. Fire alarms and sensors.
6. Security system components.
7. Water pumps and supply equipment.
8. Sanitary lift station.
9. Fuel storage tank and distribution.

issues and assumptions

1. Siting

Shelters should be located away from primary targets (e.g., aircraft, runways, weapon systems, ammunition dumps) to reduce the possibility of collateral damage from attack. It has been assumed that the shelters are not prime targets and will be subjected only to warheads intended for other targets. Shelters may be located on- or off-post as needed to provide adequate separation from prime targets. If located off-post, the cost of providing and maintaining security must be considered in planning.

Shelter concealment has not been considered because (1) construction can be observed easily by satellite, and (2) the large paved area needed for maneuvering vehicles in front of the shelter is highly visible.

Depending on the terrain, the shelter can be constructed either on the surface and mounded, partially buried and mounded, or totally buried. If possible, the shelter should be sited to provide an entrance that slopes away from the shelter. This sloping entrance would help keep debris from accumulating on the entrance pavement, maintaining a clear area for when the equipment must be removed and put into operation. Advantage should be taken of the land's natural contour. In addition, most configurations require foundation drainage to control groundwater. Consideration should be given to using tunnels in the mountainous areas.

2. Facility configuration

The operational shelter (Figures B3-1 through B3-5) has been assumed to be an integral part of the equipment shelter to reduce construction cost and still meet the endurability criteria. The two spaces share a common wall; artillery rounds striking the center of the building would hit near the center wall. Consideration was given to constructing two buildings at least 10 ft apart and connected by two tunnels--one for equipment and personnel movement, and the other just for personnel. This design would require additional excavation and structural walls, compacted backfill between the two structures, and a much larger rock rubble blanket. On the basis of cost and extended construction time, the two-shelter concept was dropped in favor of an integrated shelter.

The integrated shelter should be designed to present a flat roof, with the difference in interior vertical ceiling heights reflected in the floor elevations. Steps inside the operators' shelter will be used to compensate for the difference in floor elevations. Ramps were considered and then rejected on the basis that they require additional floor space. Ramps would make equipment movement easy, but the benefit was not worth the cost in floor space. To facilitate equipment movement, the equipment room floor should be placed at the same level as the equipment shelter with a roll-up door used to separate the two spaces.

issues and assumptions

Blast doors for personnel and vehicles (Figure B3-2) will be designed to withstand overpressures and debris from the specified threat. These horizontal sliding doors will be protected in structural concrete pockets. The vehicular door will operate electrically. The roofline will be extended to protect the doors from direct hits and to provide weather protection for the generator sets in their operating positions. The blast doors' design will consider the reflected effect of blast within the enclosed area.

Personnel doors will connect the equipment and operational shelters. Fire-rated doors will be used to isolate the two areas.

Vents with fire dampers will be provided in the wall between the operational and equipment spaces. The vents will allow air to circulate from the operational space into the equipment space, then to the outside through a blast valve. In case of fire, the dampers will close to prevent smoke from spreading between the two areas.

The floors will be treated with a sealant to reduce dust and a wearing surface will be provided for the operators' comfort. Raised floors are not required. A dropped ceiling will be used to cover the overhead air handling units, chilled water lines, and ductwork.

The equipment shelter floor will be sloped to drain and constructed with depressed wheel tracks to guide trailers being backed into the shelter. Cover plates will be provided to cover the tracks in the shelter's front section to simplify movement of personnel and generators.

The total length of operator's shelter will exceed that of the equipment shelter. To maintain a rectangular configuration and to minimize cost, the operators' shelter will be designed to wrap around the end of the equipment shelter. As a stand-alone shelter, the most economical configuration appears to be a 40-ft-wide building with a center load-bearing wall (see Figure B3-12, later).

The exterior wall and roof surfaces will be waterproofed with a sprayed-on material or a single-ply membrane and covered with insulation board before backfilling.

3. Access

Personnel access to the operators' space will be through the equipment space in the integrated shelter. Decontamination of personnel entering the shelter is not a consideration. An emergency exit to grade will be provided (Figure B3-6).

issues and assumptions

The emergency exit will be placed behind the equipment shelter to take advantage of the intersection of two structural walls. The tube extending to the surface will be filled with sand to ensure the continuity of the protective layer over the shelter. To use, personnel would release the lower door allowing the sand to fall into the equipment shelter, climb through the exit, and release the weather cap. Two wall-hung ladders will be provided to allow personnel to release the inner door from one side and not be subjected to the load of falling sand.

The "drive-through" configuration may simplify the movement of vehicles and eliminate the need for backing into the long shelter. However, the configuration would require a second vehicular entrance into the shelter complete with a large blast door, extended roof, entrance pad, and a roadway connecting it to the other entrance. The single entrance configuration was selected for this comparative analysis as being the least expensive. Figure B3-7 shows alternative entryways for this configuration.

4. Electrical power

The shelter will require power for operations and environmental control during the pre- and postattack periods. The base power system will be the shelter's main source. If the communication equipment is not to be operated other than for periodic tests, the load expected will be that for environmental control. During an attack, all operations would cease and battery-operated emergency lights would provide illumination after base power is lost. All operations will cease during the attack until the blast doors can be opened, the generators moved to outside and brought online, and the communications network reestablished. Portable diesel engine generator sets stored in the equipment shelter will provide postattack power. The generators will be moved to the exterior operating space, connected to the fuel and power supply lines, and put into operation. The stored equipment is relatively insensitive to temperature changes that could be experienced inside the shelter due to extended power outages.

The estimated power requirement is 520 kW based on the 300-kW load criteria plus the environmental control system. This requirement can best be met by two 300-kW portable diesel generator sets. A buried fuel storage tank with an 8400-gal capacity will provide for 7 days of continuous operations. A single 600-kW generator was rejected because:

a. It has lower availability/reliability; with two generators, operations could continue on a limited basis if one of the generators were to fail.

b. During periods of low power requirements, the two 300-kW generators could be used to supply a wide range of energy levels efficiently. Since generators should not be operated at less than 60 percent of their rated capacity, the 600-kW generator would be severely limited in supplying low energy levels.

issues and assumptions

Generators should be trailer-mounted to simplify over-the-road movement and maintenance and to provide the flexibility to move them to other shelters if needed.

The buried fuel tank will be protected by the same soil rock layer protecting the shelter. Tanks will be situated to provide a gravity feed to the generator operating area and to prevent shelter damage if they should be ruptured during attack.

Alternative energy sources were considered before the diesel generator sets were selected. The need to survive the attack eliminated systems that depend on collectors and other structures that are above ground and impractical to harden. Since postattack operations do not require hardened power supplies, the need for some of the more expensive hardenable power sources was eliminated. Using a power supply that can be moved outside for operation also eliminated the need for hardened air intake and exhaust structures and for an engine cooling system.

5. Environmental control

During the preattack nonoperational period, minimal HVAC functions will be provided to control the humidity inherent in buried shelters. Operational cooling during pre- or postattack will be provided by a 100-ton groundwater-cooled chiller, a chilled water distribution system, and a distributed system of air handling units. Water will be taken from one well, passed through the chiller, and returned to the ground through a second well. Two wells will provide a more reliable water source for the shelter and, in case of pumping problems with one well, cooling water could be wasted to the sewage lagoon or just to the outside.

The mechanical equipment room will have an air handling unit (AHU) and distribution system to meet low cooling loads and distribute outside air throughout the operational space. Three chilled-water AHUs will be located above the ceiling in the operational space to carry the remainder of the load. Distributed AHUs could be floor-mounted if space is available. The four AHUs can be used to meet cooling requirements efficiently as the loads vary.

Outside air will be ducted into the shelter at 375 cfm through a blast valve and CBR filter. This approach will cause a positive pressure in the operational space to reduce infusion of contaminants from the equipment space. To reduce operating costs, an outside air system rated at 10,000 cfm will also be provided for total cooling by outside air. The system will be provided with a blast valve but no CBR filter. The air will be exhausted through a blast valve by the pressure differential from the equipment shelter.

During the button-up period, no environmental equipment will operate; however, it has been calculated that the operational crew could easily survive more than 16 hours in the shelter without additional outside air or use of the mechanical equipment.

issues and assumptions

The mechanical equipment room will contain one AHU with a CBR filter, chiller, chilled water circulation pumps, compressor for control systems, and the sanitary sewage lift station. A roll-up door will be provided between the equipment shelter and the mechanical room to simplify initial installation of equipment and maintenance (Figure B3-8).

6. Water and waste disposal

Water will be supplied from a ground well and pressure tank to meet both potable and cooling water requirements. Cooling water will be returned to the ground through a second well. Two wells will provide a secondary water source that can be used if a failure occurs in the primary system. Cooling water will be wasted to the outside through the wastewater system if it is not possible to return it to the ground through one of the wells.

Wastewater will be discharged to the sewage lagoon through the lift station located in the mechanical equipment room (see Figure B3-9 for siting the lagoon). Successful operation of the facility depends on being able to discharge waste. Therefore, the lift station should be placed in the shelter for protection; an unprotected lift station located near the lagoon would require the gravity pipe to be buried deeply. After an attack, if the discharge pipe has been blocked (damaged or destroyed), the lift station will be used to pump waste to the surface through a flexible hose. The lagoon will be designed on the basis of the expected wastewater flow. However, if cooling water must be discharged through the system because of some problem, the lagoon may overflow until the problem can be corrected.

Flexible connections will be used in the piping systems near the building to reduce possible damage from ground shock (Figures B3-10 and B3-11).

7. Security

It has been assumed that project planners will satisfy security requirements and, thus, this information has not been included here.

issues and assumptions

requirements	criteria	commentary
1. Adequate space.	1. Shelter must provide 100 sq ft per operator, plus sanitary facilities and mechanical space. There are no requirements for living quarters, rest areas, food storage/preparation, general storage, or maintenance.	
2. Structure.	2. Shelter should be semihardened to withstand the specified threat.	
3. Openings.	3. Shelter will have one emergency escape exit to the surface. Two personnel doors will be provided between the operational space and the equipment storage area for fire and environmental control. Two separate personnel entrances will be provided on the stand-alone shelter configuration for fire safety (Figures B3-12 through B3-14). Openings will be provided in the roof extending over the generator operating area to pass exhaust to the exterior, thus preventing a build-up of fumes in the entrance area.	
4. Ventilation system and humidity control.	4. A filter must be installed to remove dust from the air. Ventilation and humidity requirements will conform to existing criteria for operational spaces. A CBR filter will be provided in the ventilation air system for use during the button-up period. Openings will be provided (covered with fire dampers) between the major areas for air circulation.	
5. Illumination.	5. A 50-lux general light level must be provided with 100-V outlets for adjustable lights.	
6. Power.	6. A 300-kW supply is needed for all lighting, equipment operation, and environmental control equipment. Electrical outlets, 100-V a.c., will be provided for equipment on 10-foot centers throughout the shelter. Backup power will be provided by a portable generator. Energy needed to reject the waste heat, etc. will add approximately 300 kW, raising the needed power generation to 600 kW. Fuel storage and cooling system should be sized to support at least 7 days of continuous operations without external support.	
7. Heating and cooling.	7. The environment shall be maintained within the standard temperature range for the operational spaces. Ground loop or well water cooling systems should be considered.	

requirements	criteria	commentary
8. Survivability protection.	8. HEMP and CBR controls must be provided. Shelter must be capable of being totally buttoned up for 4 hours without a power source. The environment must be maintained to support personnel in a nonoperational mode during the button-up period.	
9. Security.	9. To be provided by others, depending on the situational requirements.	
10. Drainage.	10. Site must be well drained to control ground- and run-off water.	
11. Potable water.	11. Approximately 1125 gal of water are needed daily for the operators. The need to treat well water will vary by location.	
12. Sanitary waste removal.	12. Provisions must be made for safe disposal of sanitary waste.	

guidance

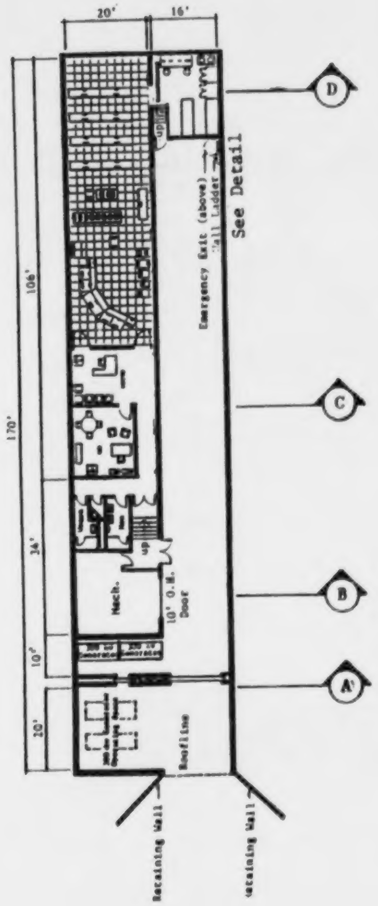

20'
16'
170'
106'
34'
10'
20'
D
C
B
A'
Emergency Exit (above)
Wall Ladder
See Detail
Mech.
10' O.H. Door
up
Generator
Generator
Roofline
Retaining Wall
Retaining Wall

FIGURE B3-1. FLOOR PLAN--OPERATIONAL SHELTER.

guidance

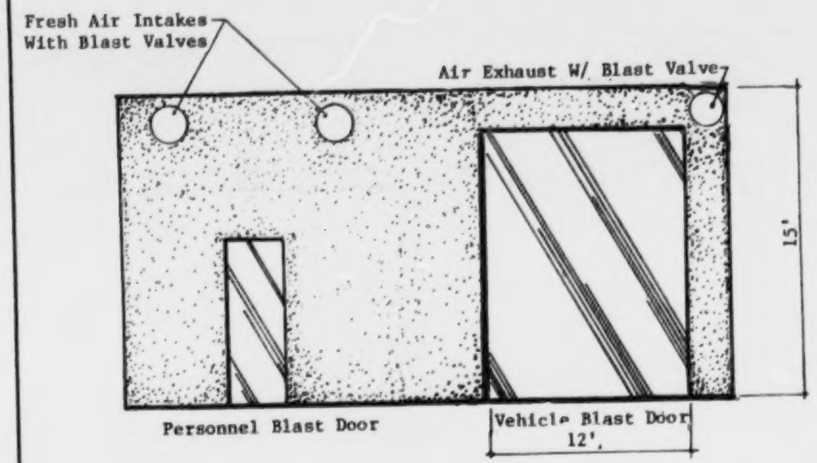

Fresh Air Intakes With Blast Valves
Air Exhaust W/ Blast Valve
15'
Personnel Blast Door
Vehicle Blast Door
12'

FIGURE B3-2. SECTION A-A.

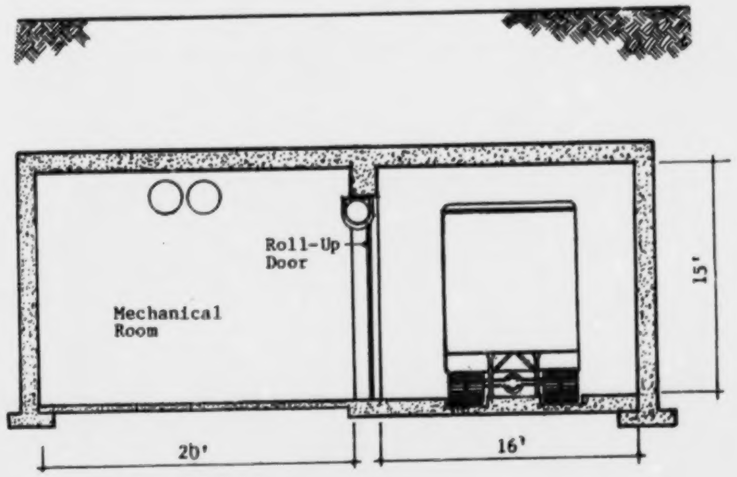

Roll-Up Door
Mechanical Room
15'
20'
16'

FIGURE B3-3. SECTION B-B.

guidance

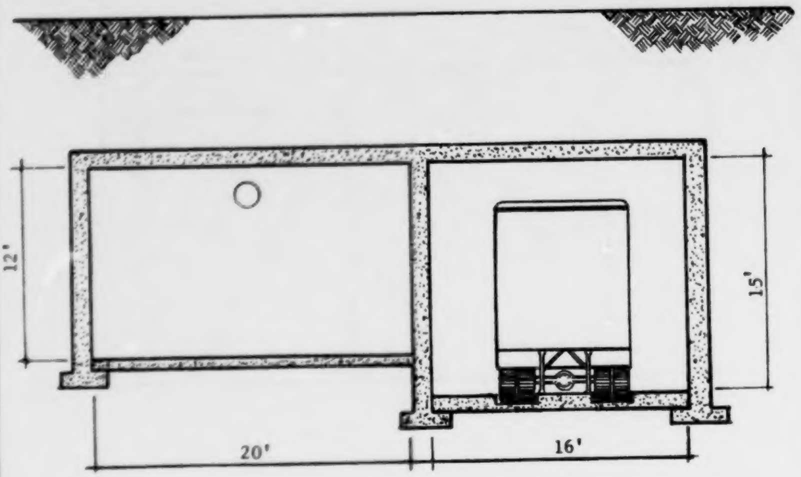


FIGURE B3-4. SECTION C-C.

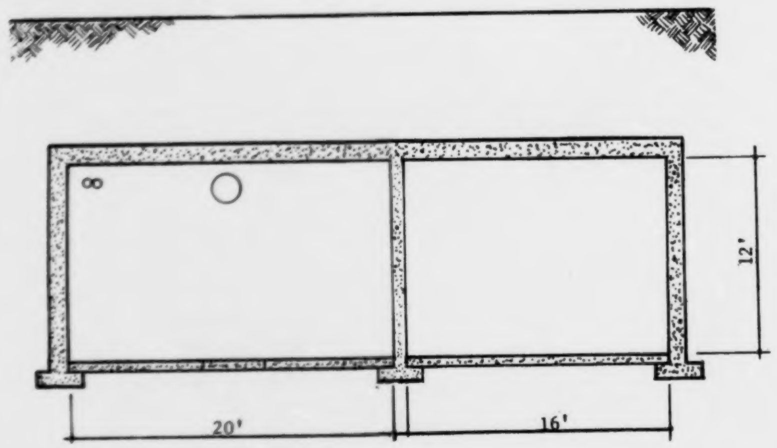


FIGURE B3-5. SECTION D-D.

guidance

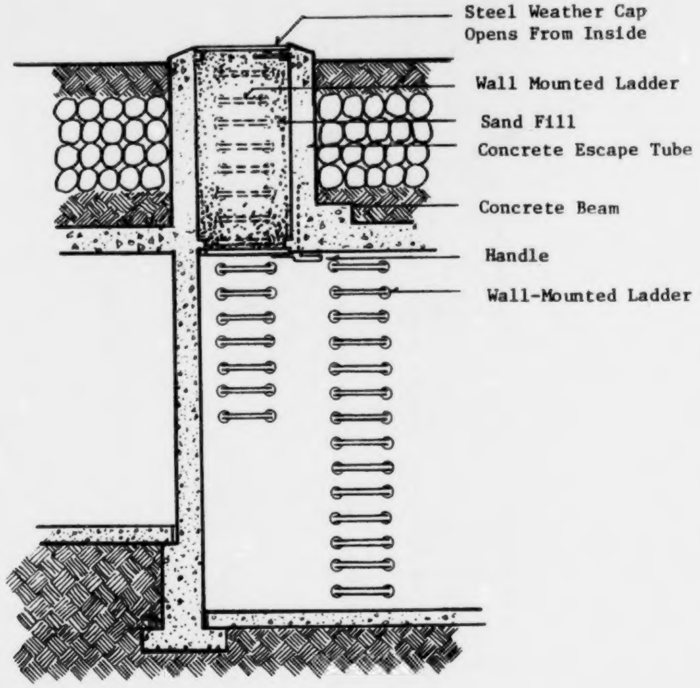
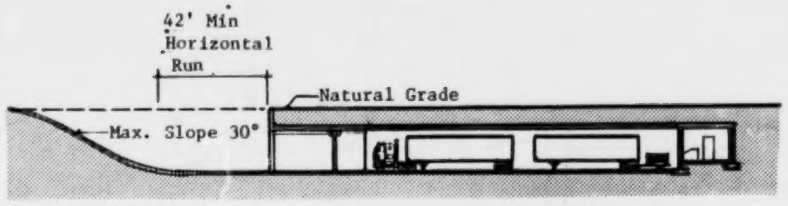
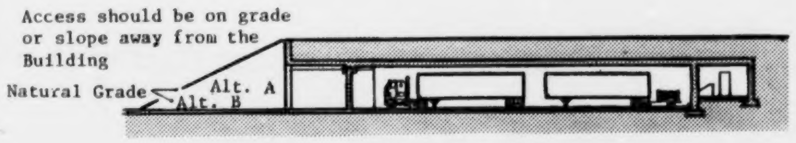

Steel Weather Cap
Opens From Inside
Wall Mounted Ladder
Sand Fill
Concrete Escape Tube
Concrete Beam
Handle
Wall-Mounted Ladder

FIGURE B3-6. EMERGENCY EXIT DETAIL.

guidance


42' Min
Horizontal
Run
Natural Grade
Max. Slope 30°

LONGITUDINAL SECTION ALTERNATIVE C


Access should be on grade
or slope away from the
Building
Natural Grade
Alt. A
Alt. B

LONGITUDINAL SECTION ALTERNATIVES A & B

FIGURE B3-7. LONGITUDINAL SECTIONS.

guidance

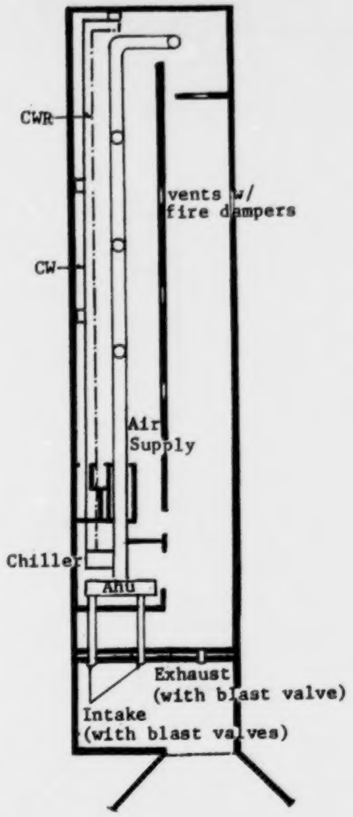

CWR
vents w/
fire dampers
CW
Air
Supply
Chiller
AHU
Exhaust
(with blast valve)
Intake
(with blast valves)

FIGURE B3-8. MECHANICAL PLAN.

guidance

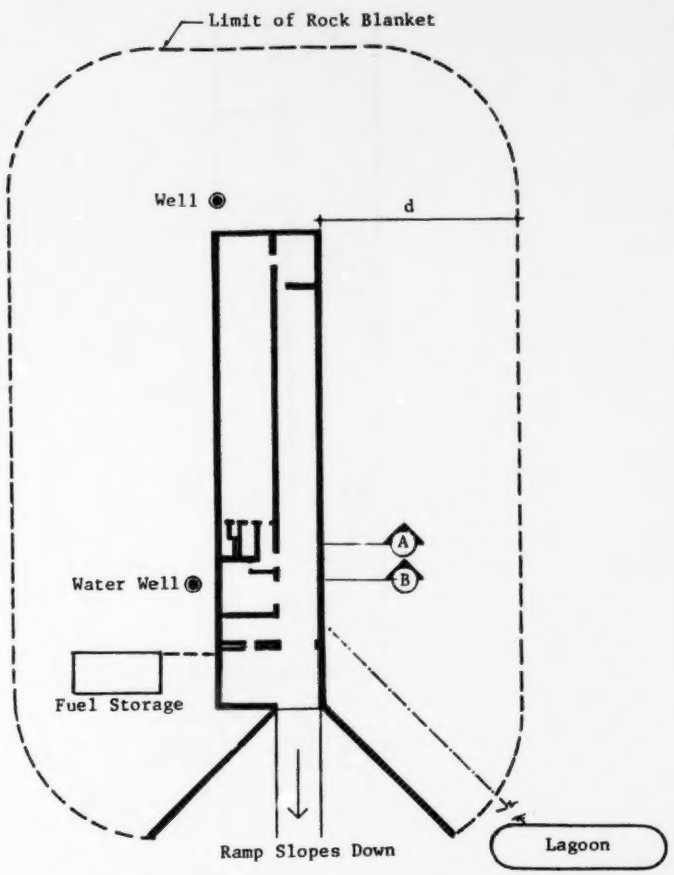

Limit of Rock Blanket
Well
d
Water Well
A
B
Fuel Storage
Ramp Slopes Down
Lagoon

FIGURE B3-9. SITE PLAN.

guidance

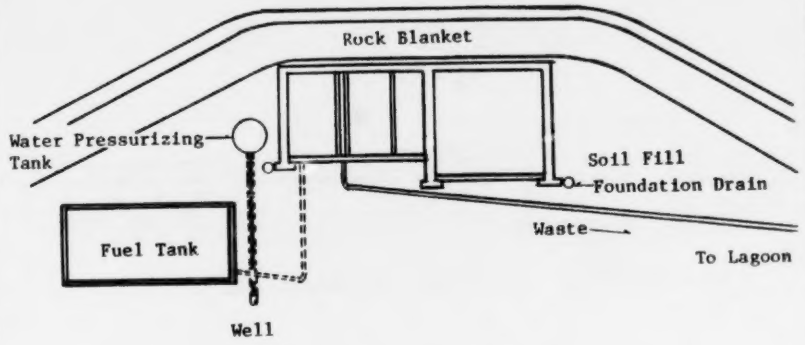

Rock Blanket
Water Pressurizing Tank
Soil Fill
Foundation Drain
Fuel Tank
Waste
To Lagoon
Well

FIGURE B3-10. SECTION--MOUNDED CONSTRUCTION.

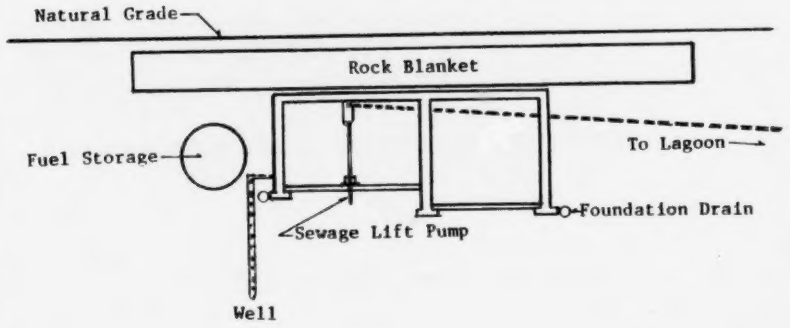

Natural Grade
Rock Blanket
Fuel Storage
To Lagoon
Foundation Drain
Sewage Lift Pump
Well

FIGURE B3-11. SECTION--BELOW-GRADE CONSTRUCTION.

guidance

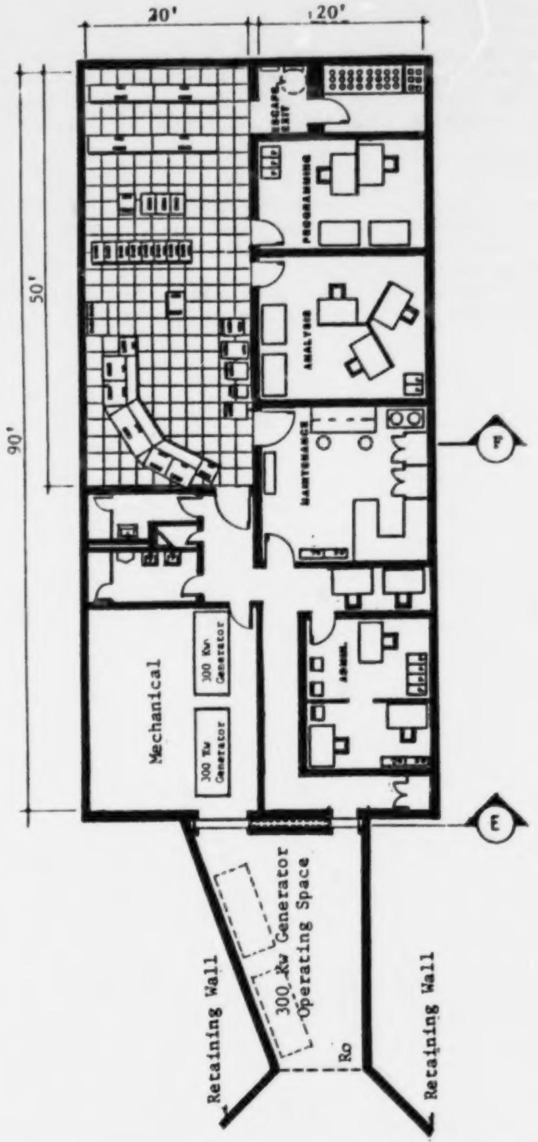

20'
20'
50'
90'
ESCAPE EXIT
PROGRAMMING
ANALYSIS
MAINTENANCE
ADMIN.
Mechanical
300 Kw Generator
300 Kw Generator
F
E
300 Kw Generator Operating Space
Retaining Wall
Retaining Wall
Ro

FIGURE B3-12. FLOOR PLAN--STAND-ALONE CONFIGURATION.

guidance

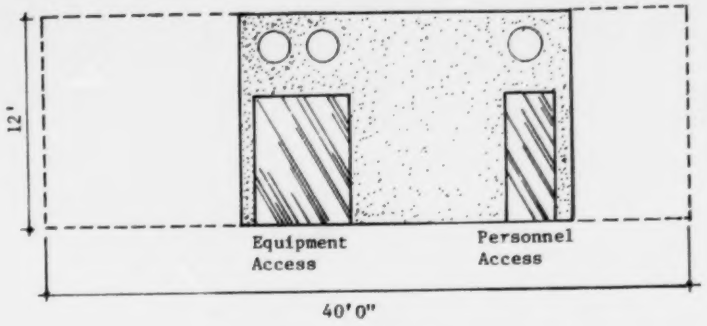

12'
Equipment Access
Personnel Access
40'0"

FIGURE B3-13. Section E-E.

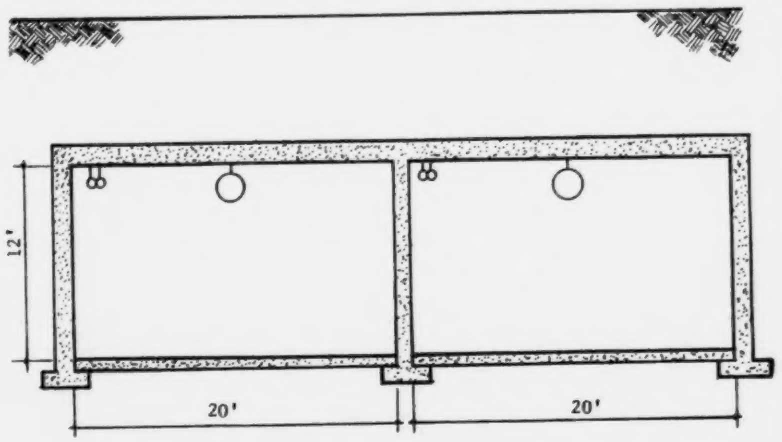


FIGURE B3-14. SECTION F-F.

guidance

guidance

1. Environmental control system

Burying a shelter greatly reduces the exterior environment's influence on the interior. The operational space will require an environment in the postattack period equal to any other communication space. The vehicle storage bay requires no environmental treatment.

2. Power systems

Commercial power will be used during the preattack period. The only power requirement during the attack period is for battery-powered lighting. Since the operational space will be used in the post-attack period, two portable generators should be provided. These generators will operate outside the shelter with weather protection only; however, hardened fuel storage will be required to support the generators.

SECTION C BASELINE CONSTRUCTION

guidance

Requirements

All facility concepts must be evaluated in terms of the four performance attributes by a comparison with conventional construction. For comparison, baseline descriptions were developed for two facilities representing different construction technologies. The first is a conventional preengineered, steel-framed, metal-sided building designed to protect the equipment from the weather. The other is a standard reinforced-concrete ammunition igloo with an exposed blast door. Neither facility would protect against the specified threat. The cost estimates are based on the rationale stated in Section E, ANALYSIS AND CONCLUSIONS.

C1 Baseline metal building

The building selected is a low, rigid-frame, preengineered steel structure manufactured and erected by several firms (Figure C-1). Figure C-2 shows a typical wall section. The structure has a reinforced concrete foundation and floor slab and a rigid steel frame with bents on 20-ft centers. The clear height is 15 ft and the width is 20 ft. The wall system is 26-gage factory-fabricated and -finished steel panels with 4 in. of insulation and vapor barrier. Interior surfaces are covered with 26-gage wall panels up to 8 ft high to protect the insulation. The roof is a 24-gage steel panel system with 6 in. of insulation covered with a vapor barrier. The personnel and vehicle doors are metal-clad and insulated.

guidance

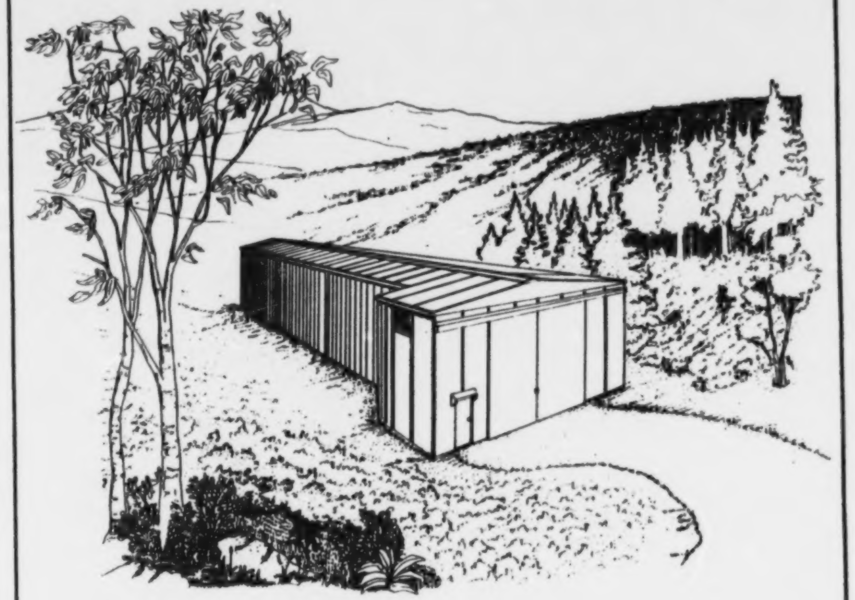


FIGURE C-1. ELEVATION--METAL BASELINE BUILDING.

guidance

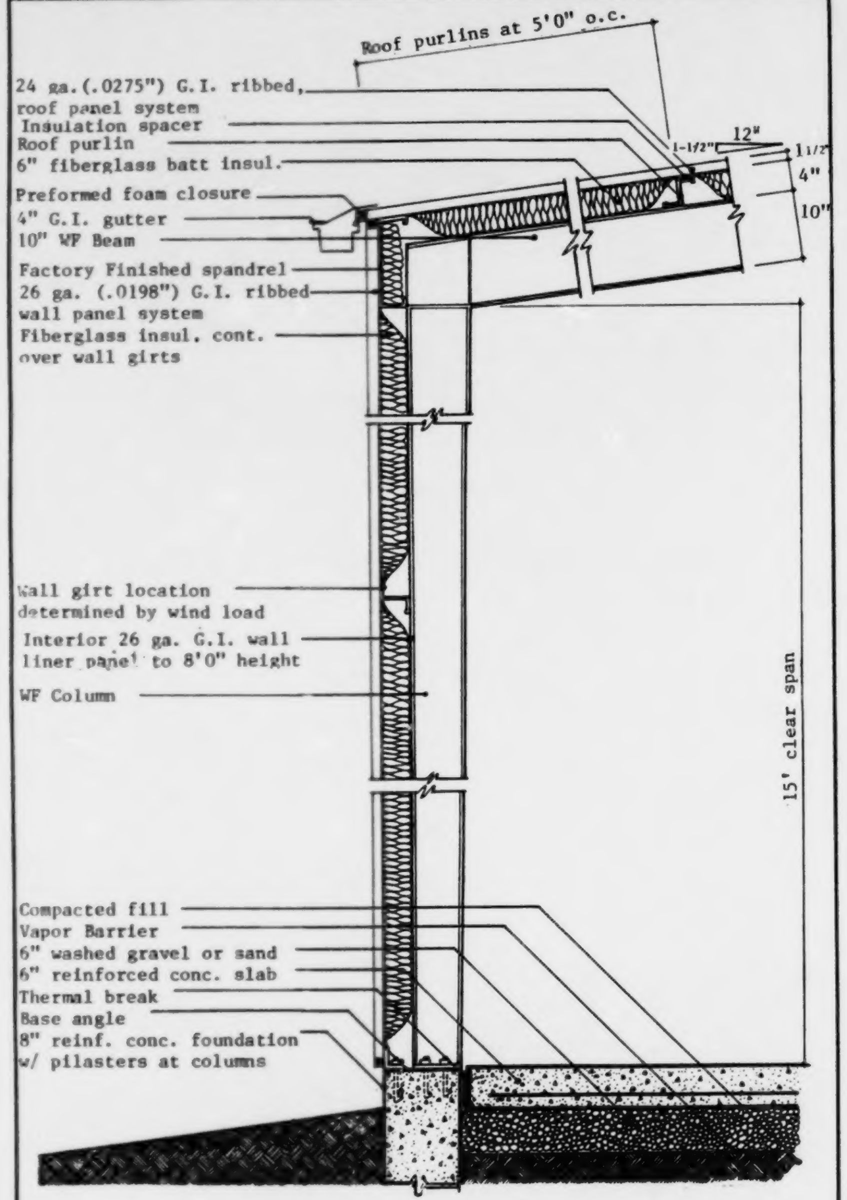

Roof purlins at 5'0" o.c.
24 ga.(.0275") G.I. ribbed, roof panel system
Insulation spacer
Roof purlin
6" fiberglass batt insul.
Preformed foam closure
4" G.I. gutter
10" WF Beam
Factory Finished spandrel
26 ga. (.0198") G.I. ribbed wall panel system
Fiberglass insul. cont. over wall girts
1-1/2"
12"
1 1/2"
4"
10"
Wall girt location determined by wind load
Interior 26 ga. G.I. wall liner panel to 8'0" height
WF Column
15' clear span
Compacted fill
Vapor Barrier
6" washed gravel or sand
6" reinforced conc. slab
Thermal break
Base angle
8" reinf. conc. foundation w/ pilasters at columns

FIGURE C-2. WALL SECTION.

guidance

C2 Baseline concrete building

The standard ammunition igloo is constructed of cast-in-place reinforced concrete using reusable metal forms. One end wall is left exposed and contains the blast door. The igloo is designed to protect the stored ammunition from accidental detonation due to external causes and to limit the damage that could result if the ammunition were detonated inside the igloo. Embankments often are constructed across the road from the blast door to reduce the possibility of this door becoming a target for enemy fire and to limit the damage that could cause a detonation inside the igloo during vehicle loading/unloading activities (when the door is open). Three different siting conditions were considered. In Condition A, the igloo is constructed on-grade and mounded (Figure C-3). In Condition B, the igloo is partially buried and mounded (Figure C-4). In Condition C, the igloo is totally buried (Figure C-5). The structure was designed to carry little more than the weight of the earth cover and cannot withstand a major dynamic load.

Estimated costs for the shelters are summarized below. See the appendix for detailed cost estimates.

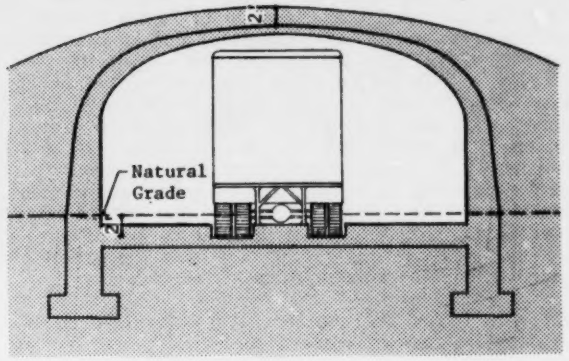
RECONSTITUTIONAL UNIT STORAGE (900 SQ FT)

	Total Cost	Unit Cost
Condition A	$259,000	$287.78
Condition B	$258,000	$287.67
Condition C	$257,000	$285.56

TRANSPORTABLE UNIT STORAGE (2500 SQ FT)

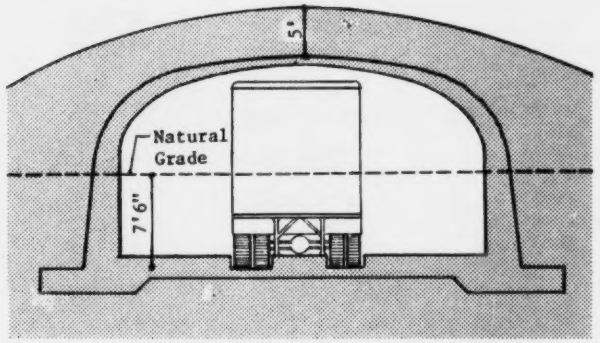
	Total Cost	Unit Cost
Condition A	$405,000	$162.00
Condition B	$405,000	$162.00
Condition C	$410,000	$164.00

guidance


2'
Natural
Grade
2'

ALTERNATIVE A

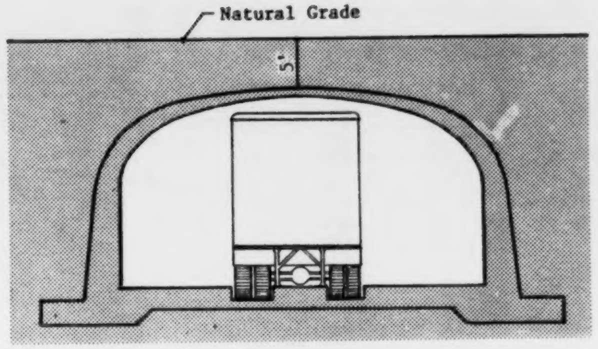
FIGURE C-3. ALTERNATIVE A--BASELINE CONCRETE BUILDING.


5'
Natural
Grade
7'6"

ALTERNATIVE B

FIGURE C-4. ALTERNATIVE B--BASELINE CONCRETE BUILDING.

guidance


Natural Grade
5'

ALTERNATIVE C

FIGURE C-5. ALTERNATIVE C--BASELINE CONCRETE BUILDING.

SECTION D
CONSTRUCTION ALTERNATIVES

issues and assumptions

Requirements

Hardened and semihardened shelters are invariably constructed of concrete in various configurations using several forming techniques. This section identifies several alternative construction techniques that can be used to reduce both construction time and cost. These alternatives include conventional concrete mixes as well as fibrous concrete. Fibrous concrete replaces reinforcing steel bars with short steel fibers mixed into the concrete matrix. The short fibers give fibrous concrete much higher resistance to cracking; moreover, this material's performance does not depend on the bond developed between the matrix and reinforcing steel bars. Fibrous concrete can be placed in forms, pumped, or applied through shotcreting equipment.

D1 Shotcrete construction

Shotcreting techniques can reduce construction time. In conventional construction, shotcreting reduces the time it takes to deliver the concrete into the forms and simplifies placement that otherwise would require erection of ramps, etc., to move heavy loads. Using fibrous reinforced concrete could further reduce construction time by eliminating the need for reinforcing bars in the forms. Fibrous concrete can be pumped in a shotcreting operation or placed in mass using the same techniques commonly used in concrete construction. However, shotcreting requires special equipment that may not be readily available in all locations. In addition, fibrous concrete, though used in the United States, may be an unknown material in some locations. Finally, the ductility factor assigned to shotcrete is somewhat lower than that assigned to cast-in-place concrete, so that shotcrete would require additional structural thicknesses to provide equal protection.

D2 Precast construction

The shelter could be constructed of structural elements precast either onsite or in commercial casting yards and transported to the site. Elements would be cast horizontally to simplify the placement of reinforcing steel and allow entire panels to be cast in one operation. If they were constructed vertically, the shelter walls would require that concrete be placed in lifts with the lower concrete allowed to set before the remaining height could be placed. Precast techniques eliminate the need to construct all forms by producing standard precast elements. These elements require that adequate lifting equipment be onsite for lifting them into place. In addition, precast elements that must be truck-transported from offsite casting yards will be limited in weight and width. (The precast elements' weight may become a major problem as their thickness increases.)

issues and assumptions

The primary weakness in this construction technique is the limited strength that can be developed in the connections. Wall-to-roof joints between precast concrete elements often are simple, but other joints are secured in place by welding together steel plates embedded in the surface of the elements. The joint's resistance to movement and rotation depends on the weld and on the plates' embedded anchors. The joint can be pinned together and stiffened with reinforcing steel bars in grouted holes (Figure D-1). However, with a lateral load, the joints will not react as a fixed joint and the wall will tend to deflect inward, causing joints to open. Roof units are keyed together to resist downward pressures (Figure D-2). These types of joints were assumed to be used in the precast concrete shelter considered in this analysis.

As an alternative technique for stiffening joints, the wall-to-roof joint could be stiffened to external lateral pressures by using a shoulder on the roof slab (Figure D-3) and a step in the floor slab. However, the shelter has not been designed to withstand internal pressure. Roof construction could also be stiffened by using precast concrete beam panels (Figure D-4) to avoid the inherent weakness of the keyed joint. Although these techniques would improve the structural joints, construction cost and time would increase with no major increase in the ductility factor.

Figures D-5 through D-7 show another type of connection--a pinned lap joint. Figures D-8 and D-9 illustrate keyed joints.

As an alternative to conventional precast construction, the shelter could be built of integral longitudinal segmental sections precast onsite. The section's length would be determined by its weight and the capacity of onsite cranes. Sections could be cast in reusable forms then lifted into place. They would fit together using a tongue-and-groove detail on the contacting surfaces. After all units are installed, a system of posttensioning tendons could be used to clamp the sections together. Figures D-10 through D-13 show details of this alternative concept. The wall panels could be cast horizontally on the foundation slab to minimize formwork and excavation.

guidance

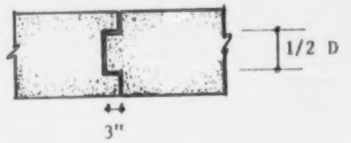


FIGURE D-2. ROOF SLAB JOINT.

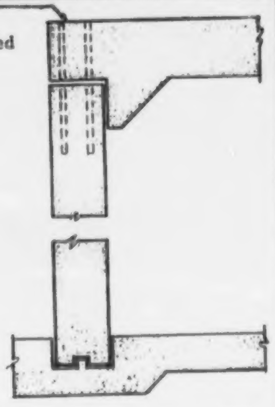

Reinforcing steel set in pre-drilled holes and grouted

FIGURE D-3. PINNED SHOULDER JOINT.

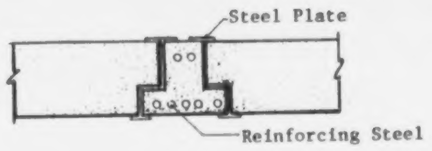

Steel Plate
Reinforcing Steel

FIGURE D-4. BEAMS FOR PRECAST ROOF PANELS.

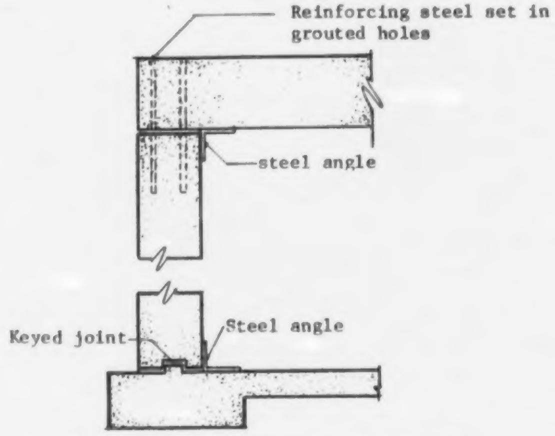

Reinforcing steel set in grouted holes
steel angle
Keyed joint
Steel angle

FIGURE D-1. PINNED PRECAST ELEMENTS.

guidance

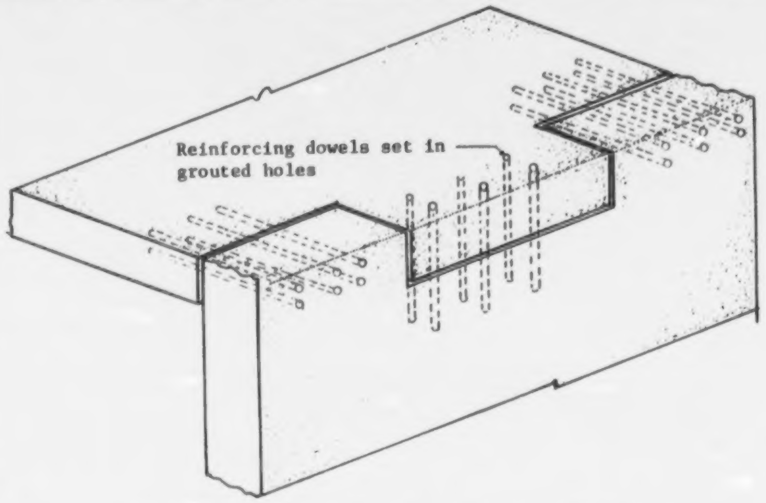

Reinforcing dowels set in grouted holes

FIGURE D-5. PINNED LAP JOINT--PRECAST ELEMENTS.

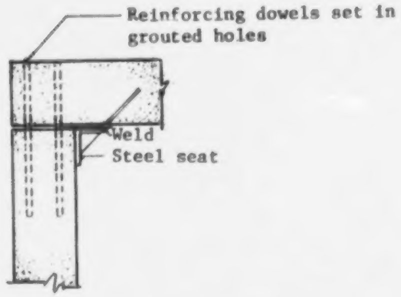

Reinforcing dowels set in grouted holes
Weld
Steel seat

FIGURE D-7. SECTION G-G--PINNED LAP JOINT.

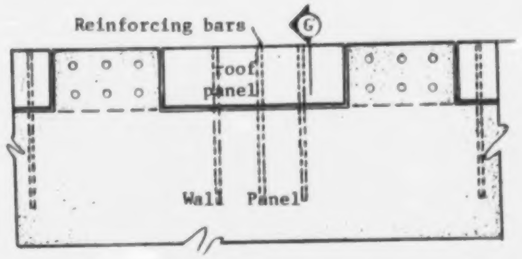

Reinforcing bars
G
roof panel
Wall Panel

FIGURE D-6. ELEVATION--PINNED LAP JOINT.

guidance

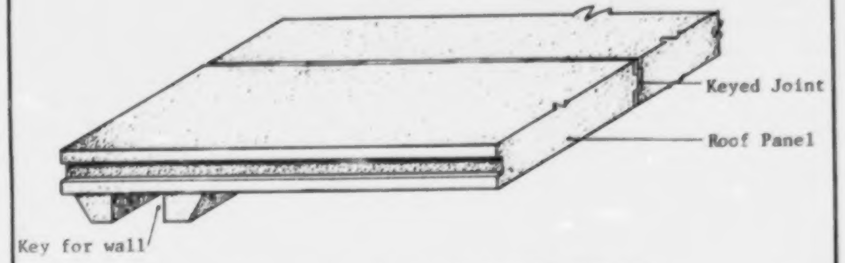

Keyed Joint
Roof Panel
Key for wall

FIGURE D-8. KEYED JOINTS FOR PRECAST ELEMENTS.

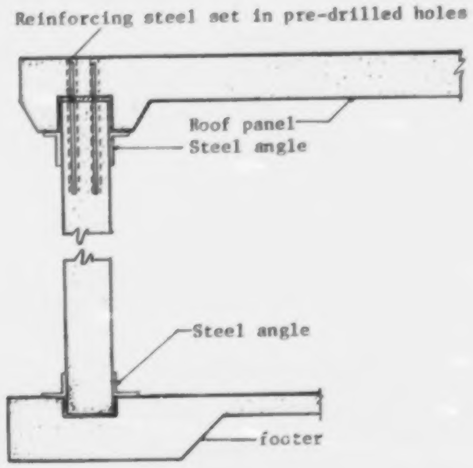

Reinforcing steel set in pre-drilled holes
Roof panel
Steel angle
Steel angle
footer

FIGURE D-9. WALL SECTION.

guidance

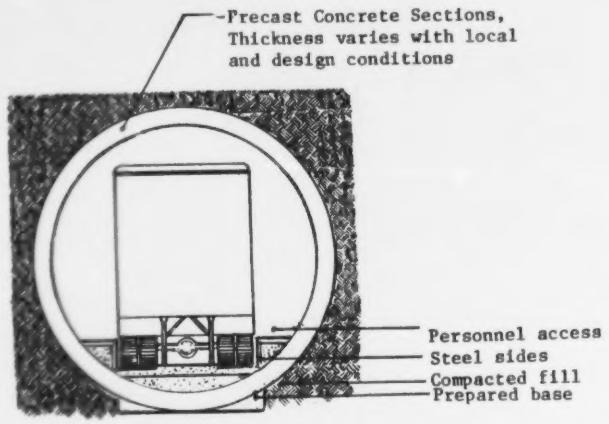

Precast Concrete Sections, Thickness varies with local and design conditions
Personnel access
Steel sides
Compacted fill
Prepared base

FIGURE D-10. PRECAST CONCRETE CIRCULAR SECTION.

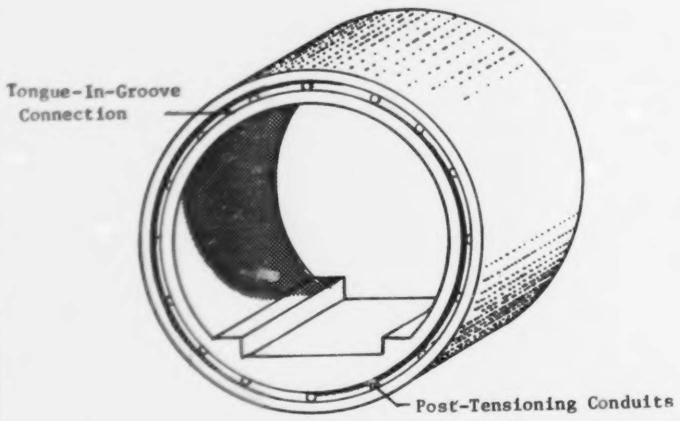

Tongue-In-Groove Connection
Post-Tensioning Conduits

FIGURE D-11. CIRCULAR PRECAST CONCRETE SHELTER.

guidance

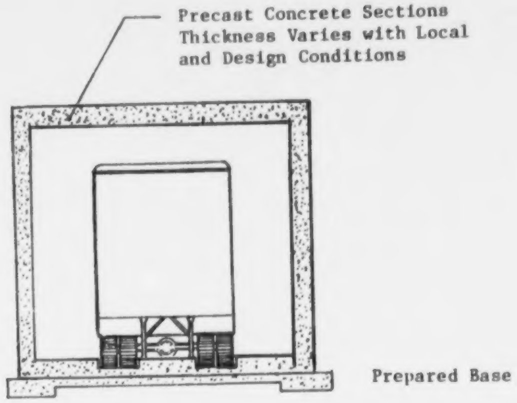

Precast Concrete Sections
Thickness Varies with Local
and Design Conditions
Prepared Base

FIGURE D-12. PRECAST CONCRETE RECTANGULAR SECTION.

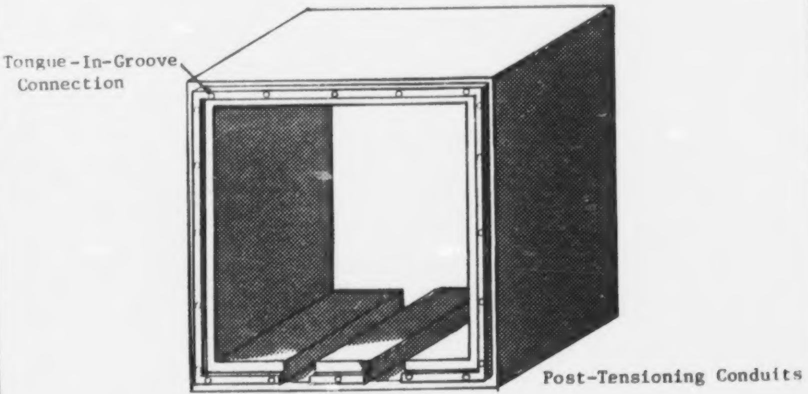

Tongue-In-Groove
Connection
Post-Tensioning Conduits

FIGURE D-13. RECTANGULAR PRECAST CONCRETE SHELTER.

guidance

guidance

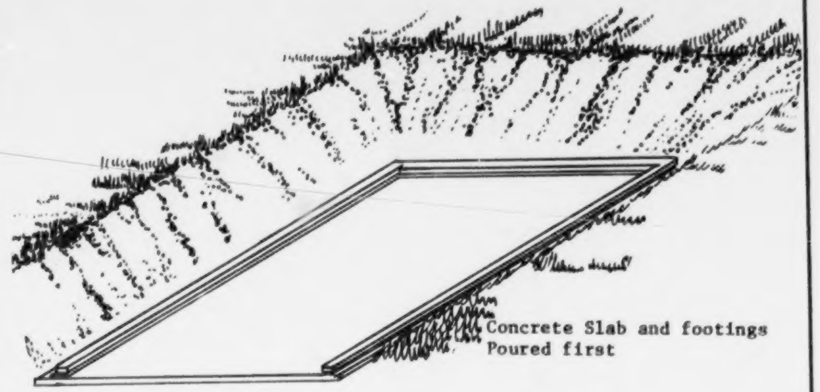
D3 Tilt-up panel construction

Structural wall panels could be cast adjacent to their final vertical position, then tilted up and anchored in place as the shelter is constructed. This variation of precasting has been used successfully in constructing commercial buildings and may be of some value to the semi-hardened shelters of interest. The wall panels could be cast horizontally on the foundation slab to minimize formwork and excavation, and the forming would be fairly simple. It is usually easier to construct horizontal panels rather than vertical panels, but much of these savings is lost when the work must be done 10 to 20 ft below grade. This technique also presents the same problems as other precast methods. For example, adequate strength can be developed across the joints for normal dead and live loads, but very little strength can be developed to resist lateral blast loads. The ductility factor has been set at unity--the lowest in the group--because of the inherent problems with the joints.

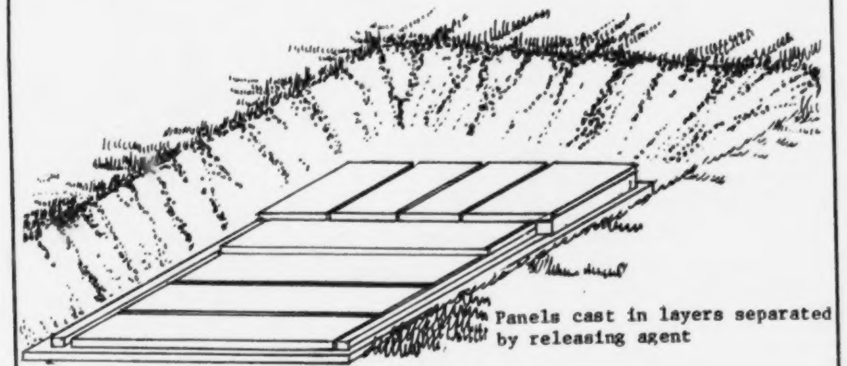
The joint problem in tilt-up construction can be eliminated partly by using the alternative construction illustrated in Figure D-14. Precast tilt-up panels are anchored securely to the floor slab through the use of turned-up reinforcing bars and a steel angle. A cast-in-place roof is used to securely anchor the reinforcing steel of the wall panels. The foundation slab is constructed with reinforcing steel turned upward to be incorporated into the joint at the base of the wall (Figure D-15). The foundation is formed to provide a keyway for the wall joint. A steel angle is then placed between the rows of reinforcing rods and welded to all exposed rods. Walls are cast with exposed reinforcing rods extending from both top and bottom of the panels (Figure D-16). These panels are cast on the foundation slab, lifted into place, and welded to the exposed foundation steel angle. After inspection, the cavity under the wall is pressure-grouted to form an integrated joint. The roof can be constructed in two different ways, both of which incorporate the reinforcing steel from the wall panels. In one method, conventional forms are placed, reinforcing steel is installed, wall steel is bent down into the roof steel mat, and concrete is placed to achieve the required slab depth. In the other method, the cost of forming is eliminated by using thin precast concrete slabs for forms and then placing the reinforcing rods and concrete on top. The thin slab also would eliminate the need for extensive shoring and forming, which should reduce overall construction time. Using either technique will ensure that fully integrated joints are formed and that the ductility factor is increased.

guidance

guidance


Concrete Slab and footings
Poured first

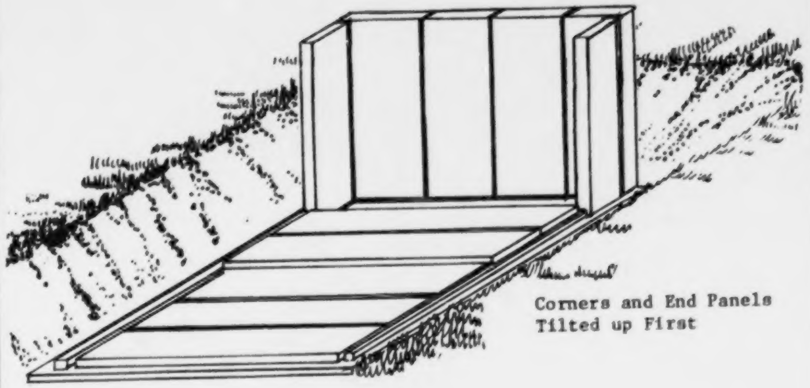
Step 1


Panels cast in layers separated
by releasing agent

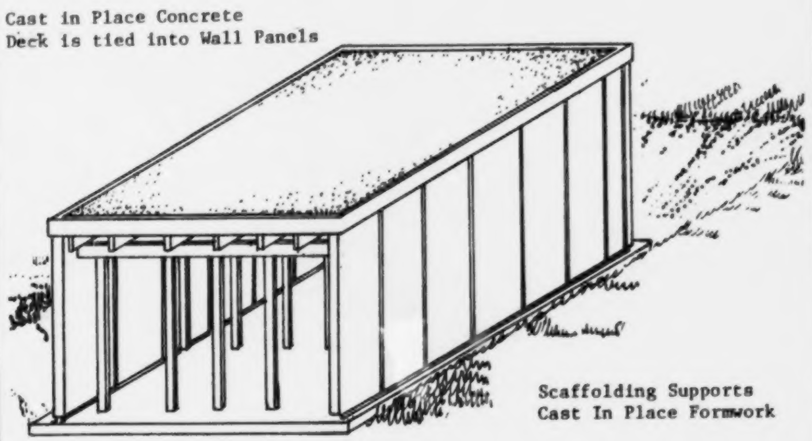
Step 2

FIGURE D-14. TILT-UP PANEL CONSTRUCTION PROCESS.

guidance


Corners and End Panels
Tilted up First

Step 3


Cast in Place Concrete
Deck is tied into Wall Panels
Scaffolding Supports
Cast In Place Formwork

Step 4

FIGURE D-14. TILT-UP PANEL CONSTRUCTION PROCESS (CONT'D).

guidance

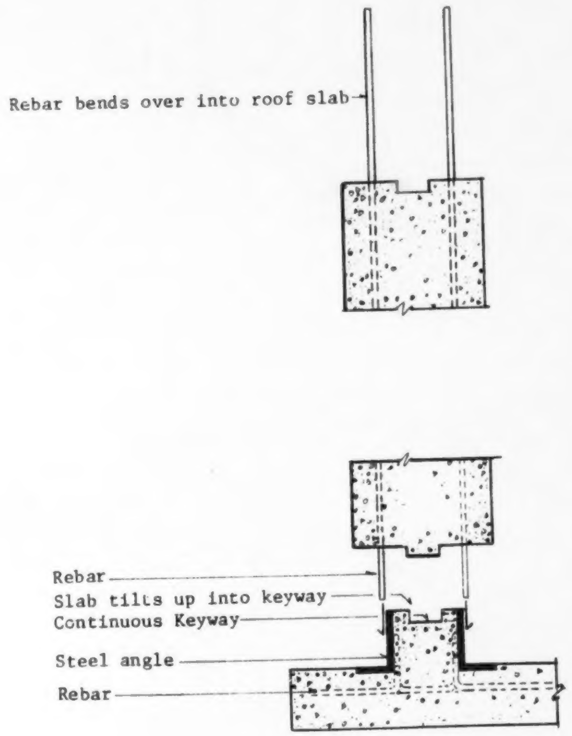

Rebar bends over into roof slab
Rebar
Slab tilts up into keyway
Continuous Keyway
Steel angle
Rebar

FIGURE D-15. PRECAST WALL PANEL--JOINTING TECHNIQUE.

guidance

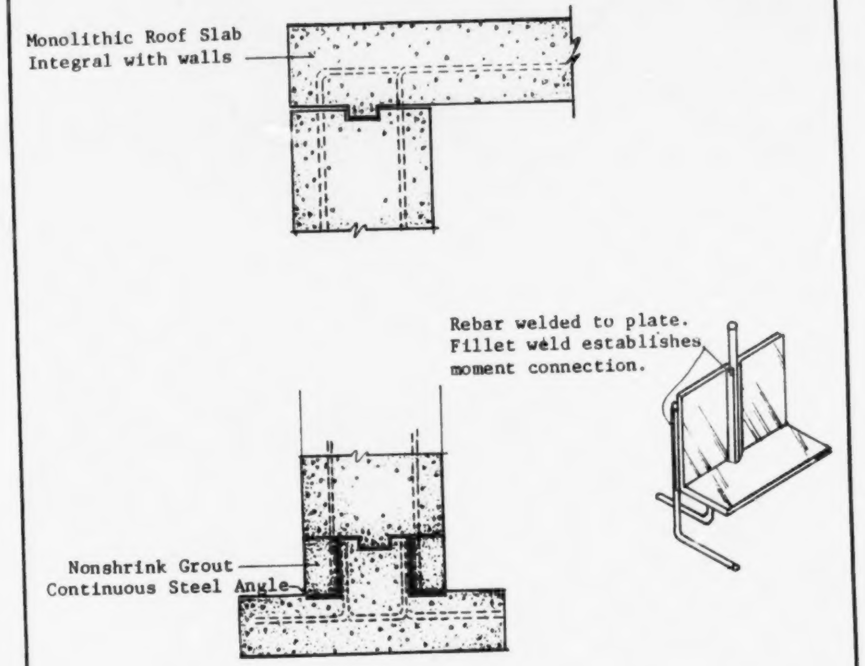

Monolithic Roof Slab
Integral with walls
Rebar welded to plate.
Fillet weld establishes
moment connection.
Nonshrink Grout
Continuous Steel Angle

FIGURE D-16. WALL-TO-ROOF FOUNDATION JOINTS.

guidance

D4 Double-panel wall construction

As an alternative to constructing thick walls to resist lateral loads, the shelter could be constructed with two thinner walls separated by a cavity filled with compacted soil. The compacted fill will transfer the load to the interior wall, allowing the walls to react as an integrated element. Walls could be cast-in-place or precast; however, the cast-in-place approach would produce the better product (Figure D-17). The cast-in-place technique has been selected for this analysis. The type of formwork used between the walls depends somewhat on the space available. Prefabricated wood or metal forms could be used if they are self-supporting and removable from the top of the wall. These special forms (Figure D-18) would have to be built in sections, heavily braced to take the lateral loads, and collapsible for removal with all controls near the top edge. Forms should be 3 ft high to allow the walls to be constructed in two lifts. After removing the forms, the cavity should be filled with compacted sand or selected soils. The finished lower section would serve as the foundation for the upper section. Or, disposable forms (Figure D-19) could be used and left in place, completely eliminating the need for special forms. Treated cardboard tabular forms appear to be a better alternative than the special collapsing type. The tabular forms can be placed in position, filled, capped and left in place, completely eliminating the need for inner forms on both walls. Concrete placed in the form will tend to fill the voids around the forms, making the composite wall more rigid. Special equipment may be required to compact the sand or soil in the forms.

guidance

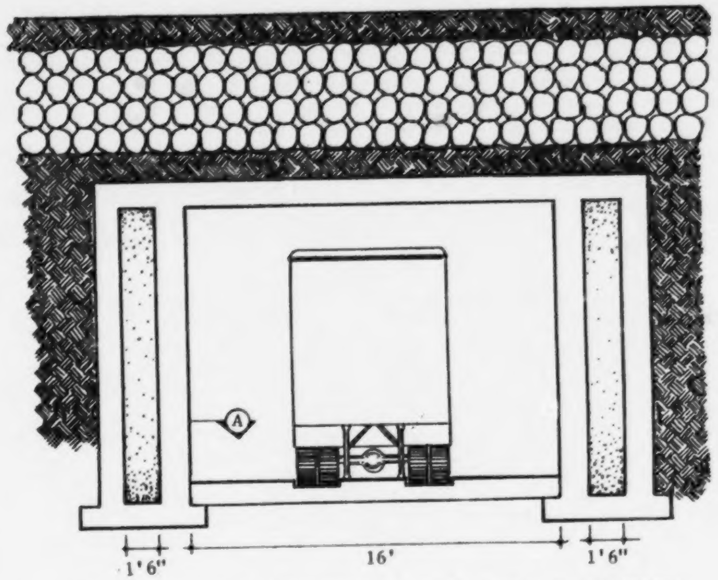


FIGURE D-17. TYPICAL SECTION--DOUBLE WALL CONSTRUCTION.

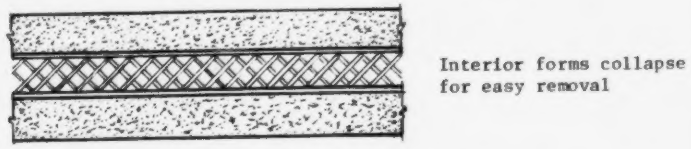


FIGURE D-18. DETAIL--COLLAPSIBLE FORM.

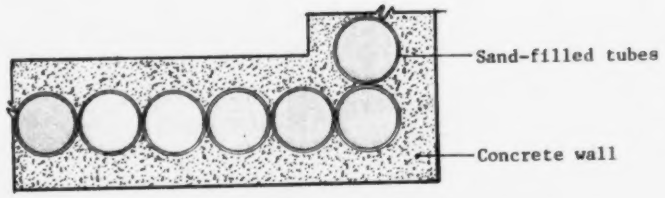


FIGURE D-19. DETAIL--DISPOSABLE FORM.

guidance

D5 Semicircular arch construction

The arch will be constructed of cast-in-place concrete and curved reinforcing steel bars placed over prefabricated forms. The exterior forming will be used in lifts to ensure placement and compaction of concrete at the lower edges. The arch inherently is able to resist heavier loads than the rectangular configuration shelters. However, the arch configuration requires more floor space to obtain the needed vertical clearances. By using a configuration similar to the baselined igloo (Figure D-20), the amount of floor space can be reduced and made more usable, but it still exceeds that required with the rectangular configuration. Figures D-21 through D-24 illustrate different arch configurations.

As an alternative, a semicircular shelter could be constructed using an inflated form, insulating foam, and sprayed-on fibrous concrete following the steps shown in Figure D-25. A conventional foundation slab is constructed with reinforcing steel stubbed up to be incorporated into the roof. An air-inflatable form is then placed on the slab and inflated to provide the form for the roof. The form is covered with sprayed-on foam to a 6-in. expanded thickness to provide insulation and to protect the form from steel wires in the fibrous concrete. After the foam cures, the form is deflated and removed. Fibrous reinforced concrete is shot onto the foam surfaces to the required thickness, incorporating the foundation reinforcing rods into the resulting structural cover. The end walls and entrance wing walls can be constructed easily using conventional techniques.

guidance

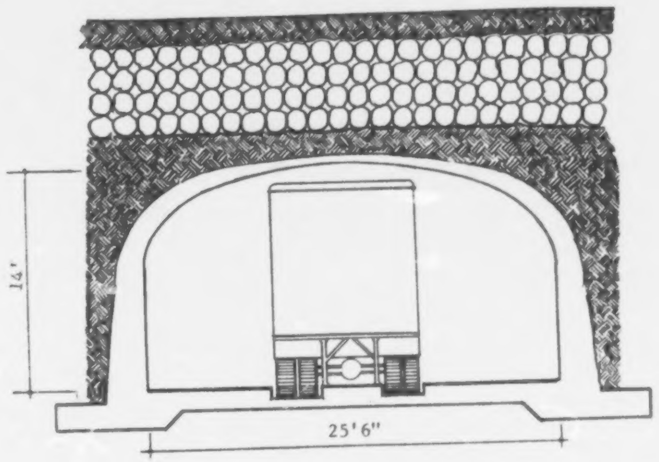
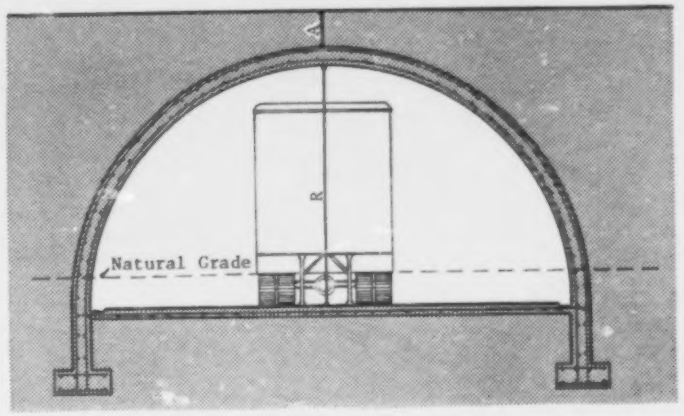


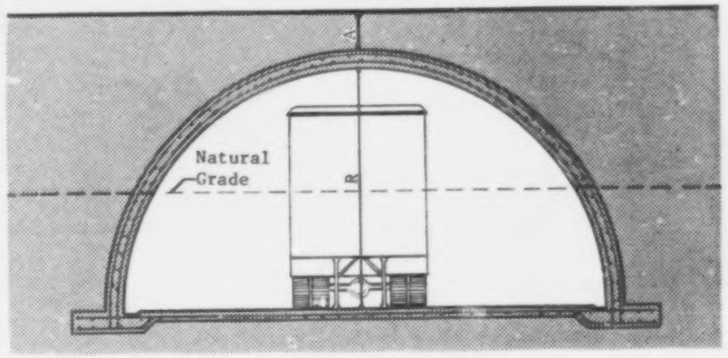
FIGURE D-20. IGLOO CONSTRUCTION.

guidance


Natural Grade
R

ALTERNATIVE A

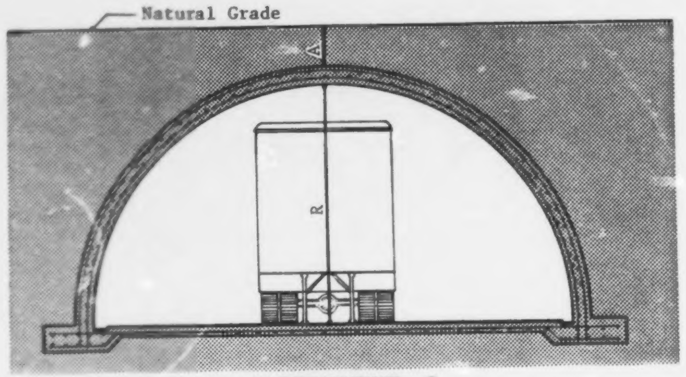
FIGURE D-21. SEMICIRCULAR ARCH--ALTERNATIVE A.


Natural Grade
R

ALTERNATIVE B

FIGURE D-22. SEMICIRCULAR ARCH--ALTERNATIVE B.

guidance


Natural Grade
R

ALTERNATIVE C

FIGURE D-23. SEMICIRCULAR ARCH--ALTERNATIVE C.

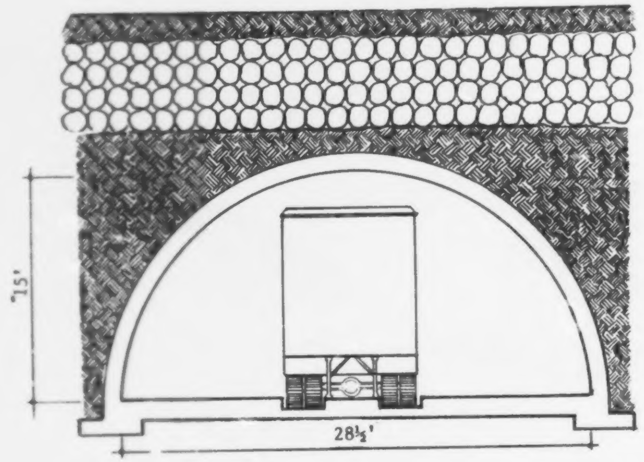
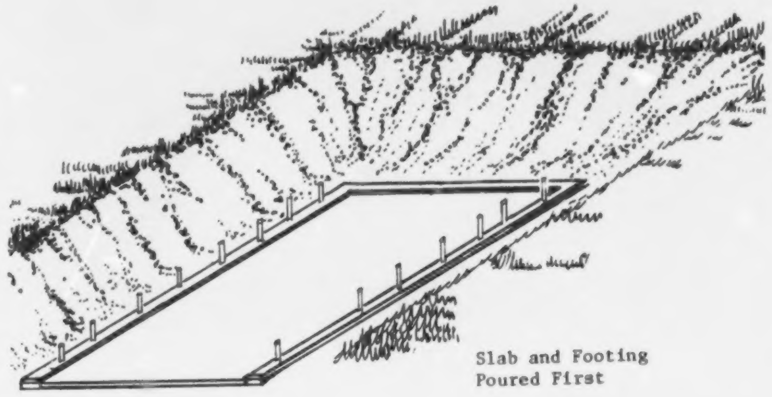
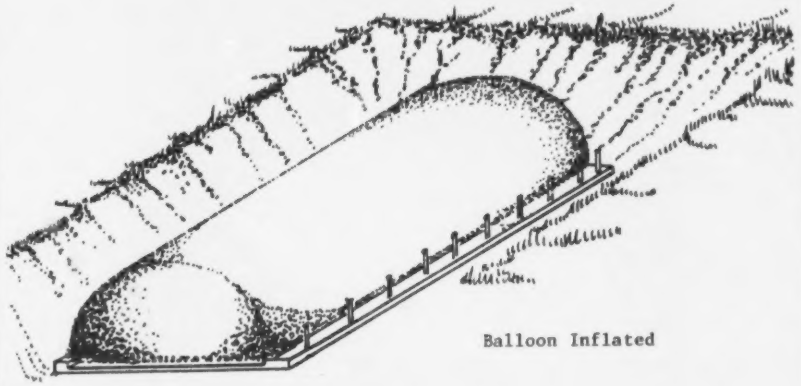


FIGURE D-24. SEMICIRCULAR ARCH CONFIGURATION.

guidance


Slab and Footing
Poured First

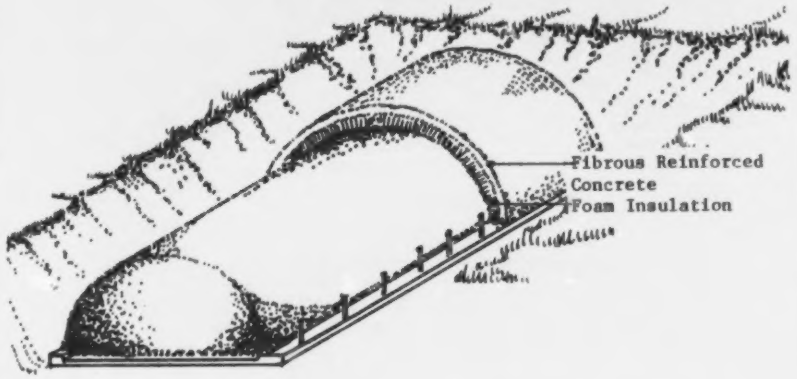
Step 1


Balloon Inflated

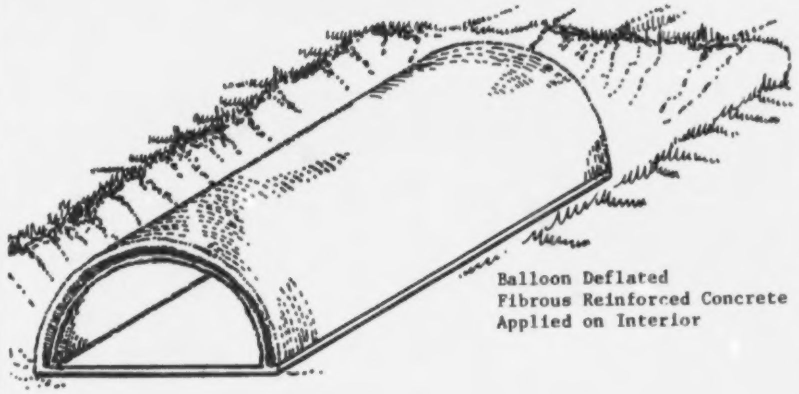
Step 2

FIGURE D-25. INFLATABLE FORM, FOAM, AND SHOTCRETE CONSTRUCTION.

guidance


Fibrous Reinforced
Concrete
Foam Insulation

Step 3


Balloon Deflated
Fibrous Reinforced Concrete
Applied on Interior

Step 4

FIGURE D-25. INFLATABLE FORM, FOAM, AND SHOTCRETE CONSTRUCTION (CONT'D).

guidance

D6 Circular construction

Large-diameter pipes and tunnel liners could be used to shelter the equipment by using fill in the bottom quadrant to form adequate interior floor space (Figures D-26 and D-27). Because of the needed diameters, the circular structures would have to be precast in sections or cast-in-place. Constructing such a shelter in place may eliminate economic advantages because of the intensive use of special forms.

As an alternative to conventional construction, the shelter could be constructed of integral longitudinal segmented sections precast on-site and interconnected with posttensioning tendons as discussed in paragraph D2.

The basic structure could be constructed of corrugated metal sections with bolted field connections and covered by fibrous concrete (Figures D-26 and D-27). Shear pins or other devices for increasing the bond between the metal and concrete would have to be installed before applying the fibrous concrete. The completed structure's strength would depend on the strength of the horizontal bolted joints. These joints would need to be staggered so that joints in adjacent panels are at least 24 in. apart.

The corrugated metal/fibrous concrete structure could be coated with 4 to 6 in. of polyurethane foam after shotcreting. This composite structure should be more resistant to blast loading since the foam layer would absorb part of the blast and reduce the deflection of the fibrous concrete, thus lowering resultant stresses on the bolted connections.

guidance

guidance

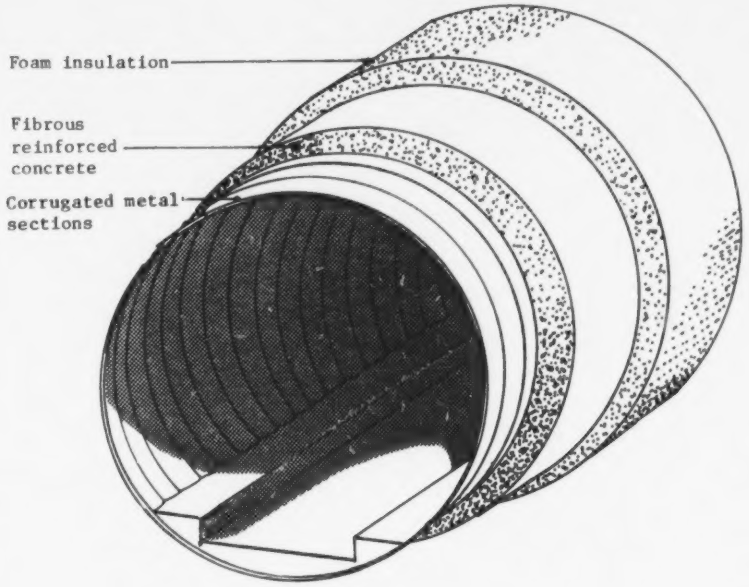

Foam insulation
Fibrous reinforced concrete
Corrugated metal sections

FIGURE D-26. CORRUGATED METAL, FOAM, AND FIBROUS CONCRETE CONSTRUCTION.

guidance

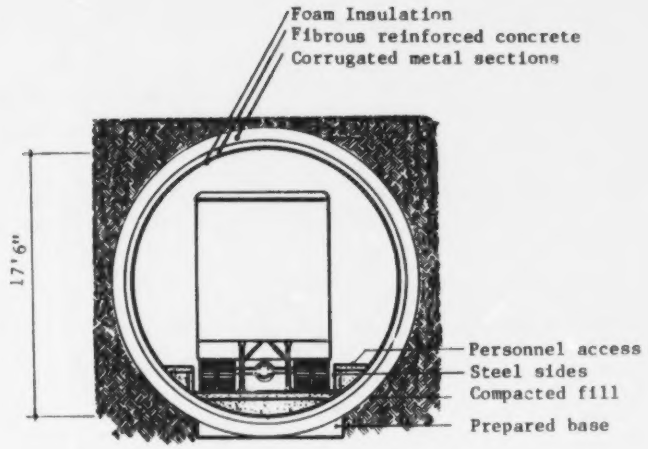

Foam Insulation
Fibrous reinforced concrete
Corrugated metal sections
17'6"
Personnel access
Steel sides
Compacted fill
Prepared base

FIGURE D-27. SECTION.

guidance

D7 Concrete/prefabricated box forms

The time required to construct the shelters by conventional techniques can be reduced by using prefabricated box forms and reinforcing steel cages placed on a prepared foundation slab. The forms would remain in place to comprise the inner liner of the shelter. The box forms would be limited to 8 ft wide to make them truck-transportable. The basic box could have a cross sectional dimension of 8 by 8 ft by 20 or 40 ft long (same dimensions as the standard MILVANs) or a higher roof height if 8 ft is restrictive. Boxes would be complete with a structural floor, wood-lined walls, and wall channels for mounting equipment. Much of the equipment could be installed in the box forms before shipment as a way to reduce both shipping volume and installation time in the field. The forms' spacing on the foundation slab will determine the thickness of the interior load-bearing walls. Conventional forming is limited to the exterior surfaces. The few different form types required to build this type of structure would include the standard box, those to build walkways between the boxes, and those for constructing the hardened entrance. Two blast doors, separated by the generator shelter, would satisfy the safety criteria. Emergency control would be based on a central chiller and small AHUs in each space. Ceiling-hung ducts would distribute the outside air.

The building configuration (Figures D-28 through D-31) in this analysis is flexible and can be changed easily to better suit local operational or geographical conditions.

guidance

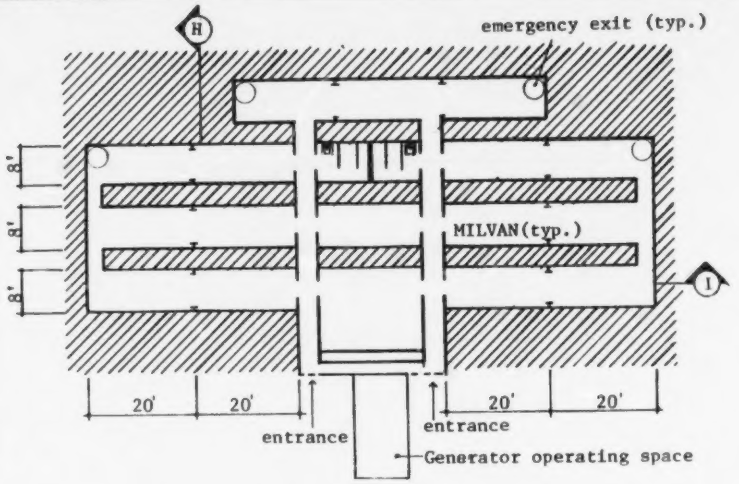

H
emergency exit (typ.)
8'
8'
8'
MILVAN(typ.)
I
20'
20'
entrance
entrance
20'
20'
Generator operating space

FIGURE D-28. PREFABRICATED BOX FORMS--FLOOR PLAN.

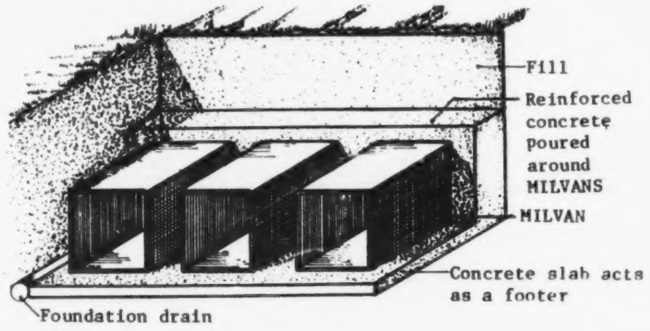

Fill
Reinforced concrete poured around MILVANS
MILVAN
Concrete slab acts as a footer
Foundation drain

FIGURE D-29. CONSTRUCTION TECHNIQUE--PREFABRICATED BOX FORMS.

guidance

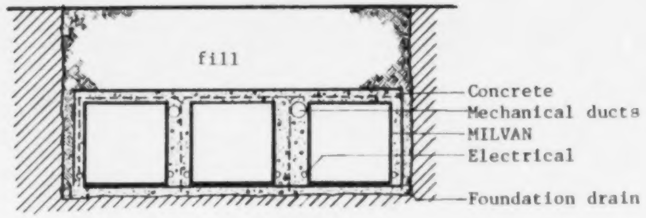


FIGURE D-30. SECTION H-H.

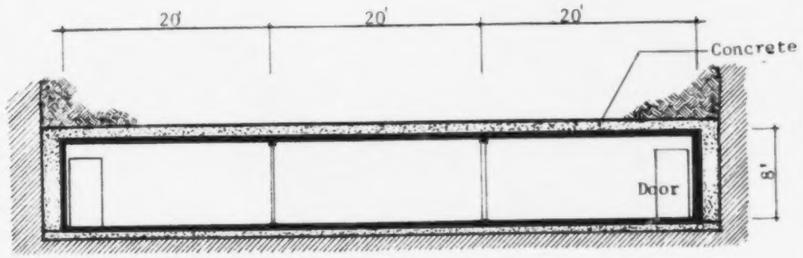


FIGURE D-31. SECTION I-I.

guidance

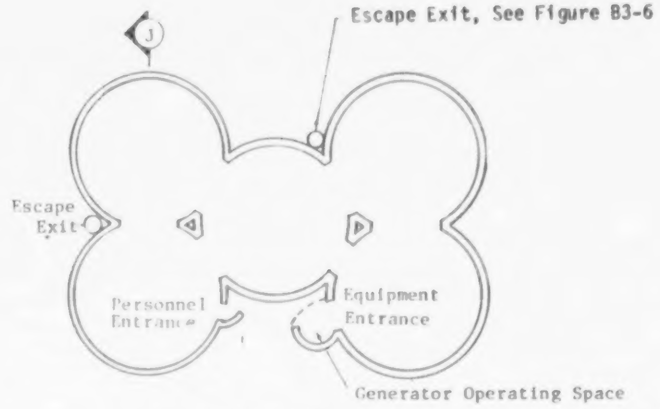
D8 Dome construction

Structural domes can provide needed operational space rapidly. Domes have been used successfully for years to satisfy a wide range of shelter requirements. Recent experience has been gained with fibrous reinforced concrete over polyurethane foam which has been sprayed onto an inflatable form. The U.S. Army Construction Engineering Research Laboratory (USA-CERL) has constructed domes up to 50 ft in diameter, and others exceeding 150 ft in diameter have been built. A dome 28 ft in diameter was selected for this analysis to keep the excavation depth approximately the same as for the rectangular section shelter built to provide operational space. The dome should be constructed on a prepared foundation. A rubber balloon form would be placed on the foundation, inflated, and covered with approximately 6 in. of polyurethane foam. After curing, the foam would be cut to form doorways and other openings and to remove the deflated balloon.

Openings can be made in foam structures in at least two ways. The foam is easily cut to form doorways, and the joints between foam surfaces and wood or metal surfaces filled with additional foam. Door frames can also be placed on the form and included in the initial spraying, since foam bonds very well with other surfaces. Two in. of fibrous concrete would be sprayed on the dome's interior and the rest of the needed concrete thickness would be sprayed on the exterior. Concrete would be applied in approximately 1-in. layers. When the concrete cures, the backfill and protective rock layers can be placed.

The resulting structure (Figures D-32 and D-33) is a heavily insulated, reinforced concrete facility complete with interior fire-proofing. The dome is hemispherical, providing a 14-ft ceiling height in the center for mechanical equipment, storage platforms, or other purposes. AHUs should be placed in the center of each dome either on the floor, on a pedestal, or on a platform to reduce the use of floor space. Chilled water lines should be placed under the floor. Partial hemispherical dome structures should be used to protect the personnel entrance and generator operating area. Interior areas could be subdivided easily using partitions to meet operational requirements.

guidance


J
Escape Exit, See Figure B3-6
Escape Exit
Personnel Entrance
Equipment Entrance
Generator Operating Space

28 ft. diameter Domes

2" fiberous concrete on inside
4" or more on the outside

AHU in center of each space

FIGURE D-32. DOME CONSTRUCTION--FLOOR PLAN.

guidance

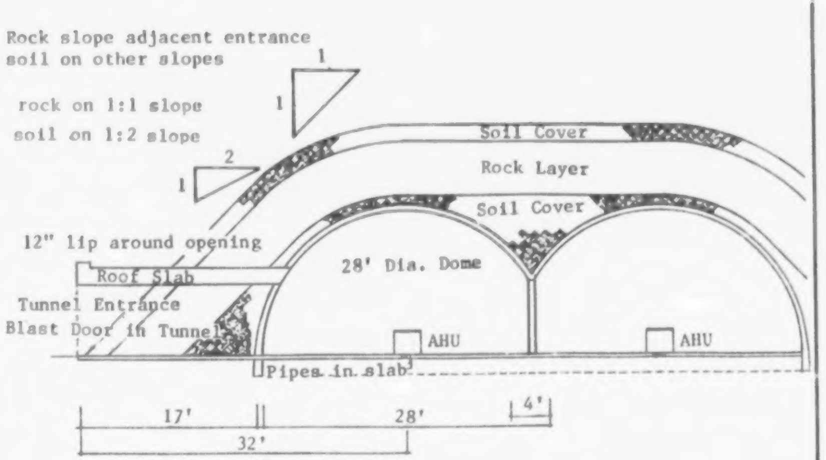

Rock slope adjacent entrance
soil on other slopes
rock on 1:1 slope
soil on 1:2 slope
1
1
2
1
Soil Cover
Rock Layer
Soil Cover
12" lip around opening
Roof Slab
28' Dia. Dome
Tunnel Entrance
Blast Door in Tunnel
AHU
AHU
Pipes in slab
17'
28'
4'
32'

FIGURE D-33. SECTION J-J.

SECTION E ANALYSIS & CONCLUSIONS

guidance

STRUCTURAL DESIGN

Structural concepts

Within the constraints of threat definition, the hardening required for the shelters dictates that a rock rubble/boulder blanket or, alternatively, a concrete burster slab be incorporated into the protective cover to defeat the effects of direct hits from artillery rounds. Therefore, this analysis focused on a series of below-ground concepts using rectangular, semicircular, and dome configurations and various construction techniques and materials described in Section D.

Point of detonation

The important variables affecting threat loading intensity on the shelter are: (1) weapon size and the distance from the point of detonation to the structure, (2) mechanical properties of the soil and rock, and (3) the projectile's depth of penetration. The rock rubble blanket will reduce the resulting blast load on the roof from direct hits by artillery rounds. If the projectile detonates too near the shelter, however, the shelter will fail due to localized breaching. The rock rubble blanket's function is to either destroy the incoming projectile at impact or reduce its penetration depth and increase the explosion standoff distance. The penetration depth into a dense medium such as the rock blanket depends on the following variables:

1. Characteristics of the projectile such as weight, caliber or diameter, length, nose shape, and structural integrity (rigidity, wall thickness, etc.)
2. Striking conditions such as impact velocity, angle of incidence, and yaw.
3. Properties of the rock rubble blanket such as the rock hardness, caliber, number of layers of and shape of boulders, and the placement method.

In general, depending on the interaction of all these variables, any of the following situations could prevail to defeat the projectile or reduce its effectiveness:

1. The projectile could break upon impact.
2. The projectile could ricochet or broach after impacting the rock rubble blanket.
3. The projectile's path could be deflected.
4. The projectile's path could be deflected and it could detonate at some location within the rubble blanket.

For the analysis in this study, it was assumed that the projectile would enter the rock blanket and detonate at approximately the midpoint of the rock rubble blanket along the centerline of the roof.

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For the case of a near miss by a bomb, the detonation point was assumed to be located along the shelter wall centerline. The nearest assumed point of detonation was set at 40 ft, which exceeds the edge of the rock rubble blanket. The rock rubble blanket would provide little protection against bomb attacks for partially and totally buried shelters; however, the rock could be extended to provide this protection if desired. Completely mounded shelters do benefit from the rock rubble blanket since rock nearly covers the shelter's complete vertical profile and would produce ground-burst from the bombs.

Thickness limitations

The following practical limitations on thickness were established for the various types of construction considered in this analysis. The actual thickness for precast and tilt-up concrete elements actually depends on the size or weight of the structural element and the availability of suitable lifting equipment.

Construction	Thickness (in.)
Cast-in-Place Concrete	60
Fibrous Reinforced Concrete	60
Precast Concrete	36
Shotcrete	36
Tilt-up Concrete	24

Design method

It is possible to design the shelter on an elastic basis using normal code limits, to withstand the large dynamic loads described in the threat; however, severity of these loads would make the design very costly. Designs that use localized plastic deformation to absorb the energy imparted by these loads are desirable; in fact, they are generally mandatory for maintaining practical structural proportions, provided the overall integrity on the structure is not impaired. Accordingly, the design and proportioning of the structural elements were based on ultimate strength design methods, the material's dynamic properties, and the structural elements' dynamic response.

A simplified, rapid procedure was used in designing the shelters to resist the dynamic loads produced by the primary threat. This method of analysis required: a description of the loading time curve on the structures and knowledge of the limiting structural resistance; the

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shape of the resistance-deflection curve for the structure, and especially a characterization of it by a ductility parameter that gives the permissible maximum deflection in relation to the structure's effective yield point deflection; and a measure of the period of vibration in the structure's effective "elastic range." This procedure is accurate enough to analyze the resistance because the parameters entering the problem cannot be determined accurately. This is due to a lack of definitive knowledge concerning: (1) the blast pressure at a given distance from a given energy detonation; (2) the blast wave duration; and (3) the structural parameters. The details of this procedure are described elsewhere.[1]

Structural deformations often are described in terms of ductility ratio, which is the ratio of the maximum deformation to maximum elastic deformation. Members that have large ductility ratios can absorb more strain energy and are thus more efficient in resisting dynamic loads. Furthermore, for buried structures, ductility is essential in order to permit the structural deformations required to take full advantage of the inherent strength of the soil surrounding the structure. Soil resistance can be mobilized only after deformations are imposed upon it.

The ductility factor that corresponds to collapse for various structures ranges from slightly greater than 1 for brittle structures to more than 20 for very ductile structures. The ductility factor used in these particular designs was assumed to be controlled by the material's ductility limit at failure rather than by functional requirements. Since the shelters are required to withstand multiple loadings, the normal ductility factors for single loading were reduced by a factor of approximately 2 to provide reasonable assurance that enough reserve energy absorption capacity would be available for multiple loadings. The ductility ratios used in the preliminary design are:

Construction Type	Ductility Factor Failure Mode	
	Ductile	Brittle
Cast-in-Place	5.0	1.0
Precast Concrete		
Segmental Units	3.0	1.0
Conventional Elements	1.5	1.0
Tilt-Up Elements	1.0	1.0
Shotcrete	2.0	1.0
Fibrous Concrete	2.0	1.0

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[1] N. M. Newmark and J. D. Haltiwanger, Principles and Practices for Design of Hardened Structures, Air Force Manual AFSWC-TDR-62-168 (Air Force Special Weapons Center, Kirkland AFB).

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CONSTRUCTION COST ESTIMATES

Assumptions

Construction cost estimates for the various shelter concepts were based on the following assumptions:

1. The proposed construction sites are located on or near existing installations. Real estate costs have not been included.
2. The proposed construction sites are located near populated areas; therefore, costs for mobilization and crew life support have not been included.
3. There are no unusual construction conditions at the proposed sites.
4. Utilities are available at the proposed construction sites.
5. There are no local, regional, or national shortages of materials that would affect construction.
6. Costs for roads, storm drainage, electrical service and communication lines, and other site development work beyond the 5-ft line of the facility have not been included.
7. No cost for possible impact on existing support has been included.
8. The daily construction output is based on an 8-hr day in daylight with no allowance for overtime.
9. The site and construction technique will have no impact on the existing transportation system.
10. Construction costs will not be affected by weather, season, contractor management efficiency, local union restrictions, local construction requirements or availability of adequate energy, manpower, and materials.

Unit costs

Unit cost data were obtained from the following sources:

1. Army Regulation (AR) 415-7, Construction Cost Estimating for Military Programming, (U.S. Department of the Army, 1980).
2. Annual Construction Pricing Guide (U.S. Air Force, 1983).

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3. Robert Snow Means Co., Means' Building Construction Cost Data (Kingston, MA, 1983).

4. Robert Snow Means Co., Means' Mechanical and Electrical Cost Data, 6th ed. (Kingston, MA, 1983).

5. Robert Snow Means Co., Means' Building System Cost Guide, 8th ed. (Kingston, MA, 1983).

6. W. J. Wooley Company, Oak Brook, Illinois, cost data on blast-resistant doors.

Specific in-place cost data were developed for the shelters' conceptual construction cost estimates. Mechanical, electrical, and blast door costs were developed on a lump-sum basis because they were generally constant for a given concept and insensitive to whether the shelters would be constructed above or below grade.

Cost estimate adjustment factors

The unit cost data were used to develop an unadjusted expected facility cost based on an assumed construction date of January 1984 and a geographical location reflecting Washington, D.C. These estimates must be adjusted by various factors to reflect actual costs in specific geographical areas, the cost growth expected due to economic factors that apply to construction projects scheduled differently from the stated assumptions, a reserve for construction contingencies to cover unexpected conditions, and supervision and administration. The values assigned to the adjustment factors were:

1. Location	1.00
2. Cost growth	1.00
3. Contingencies	1.05
4. Supervision and administration	1.05

For geographical areas other than Washington, D.C., and a midpoint date other than January 1984, Tables E-1 and E-2 can be used to determine the proper location and cost growth factors needed to adjust the estimated cost.

When evaluating the concepts for economic feasibility, note that it is not the actual construction cost which is most important, but the relative cost among alternative concepts and how they compare to baseline costs.

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Costing issues

1. Above- Versus Below-Ground Construction. To determine if a significant cost advantage is associated with locating the shelters below as opposed to above ground, a shelter for the transportable unit was designed and costed in both configurations with similar construction methods and siting conditions assumed. The results of this analysis indicated that, for all practical purposes, the costs for these configurations were identical, with any differences attributed to the design procedure accuracy. Therefore, for this investigation, the cost reported can be assumed to apply to all three configurations.

The partially mounded approach appears to be the fastest, least expensive way to construct and probably suited best for a wide range of locations.

Above-ground construction greatly simplifies site preparation and construction techniques, improves site accessibility, and reduces the cost of the entrance ramp and related pavements. The approach does require an excessive amount of soil for the mound. In addition, the soil must be furrowed and hauled to the site and the rock rubble blanket must be extended to cover the entire building configuration. The mound width could easily range from 120 to 150 ft.

Totally buried construction eliminates the need for constructing a large mound. The waste from the excavation can be used to backfill around the structure and reslope the surface for natural drainage. The entrance ramp, sloped at 30 degrees, would require a 50-ft extension to return to grade. However, this ramp, being a long open pit, could easily collect debris during an attack and this would have to be removed before the truck can be moved and the stored equipment used. In addition, cranes used for lifting heavy precast sections would have to be located more than 30 ft from the centerline of the building, which may limit the precast elements' size. Constructing the facility in a 30-ft-deep pit also would increase the cost of material handling and require additional equipment.

Partially buried construction would permit a better balance between the earthwork cut and fill, often eliminating the need to transport fill material to the site. Construction would start about 8 ft below grade, which is not an unusual depth, and conventional techniques can be used. The entrance ramp would be very short compared with that required for the totally buried building. In addition, totally buried shelters may be impractical to construct in the field due to the local terrain and the presence of a high groundwater table, saturated soil, and/or rock.

2. Cast-in-Place Concrete Unit Prices. To determine the sensitivity of the total facility cost to the in-place unit cost of cast-in-place concrete, excluding steel reinforcement, the cost of the concrete in the transportable unit shelter was varied by plus- and minus-50 percent of the estimated value. The resulting change in the total facility cost was approximately 10 percent in each case.

3. Width of the rock rubble blanket. The rock rubble blanket was extended to a distance approximately 20 ft beyond the shelter's vertical projection to provide reasonable assurance that the shelter would not be damaged by a direct hit. However, it may be desirable to extend the

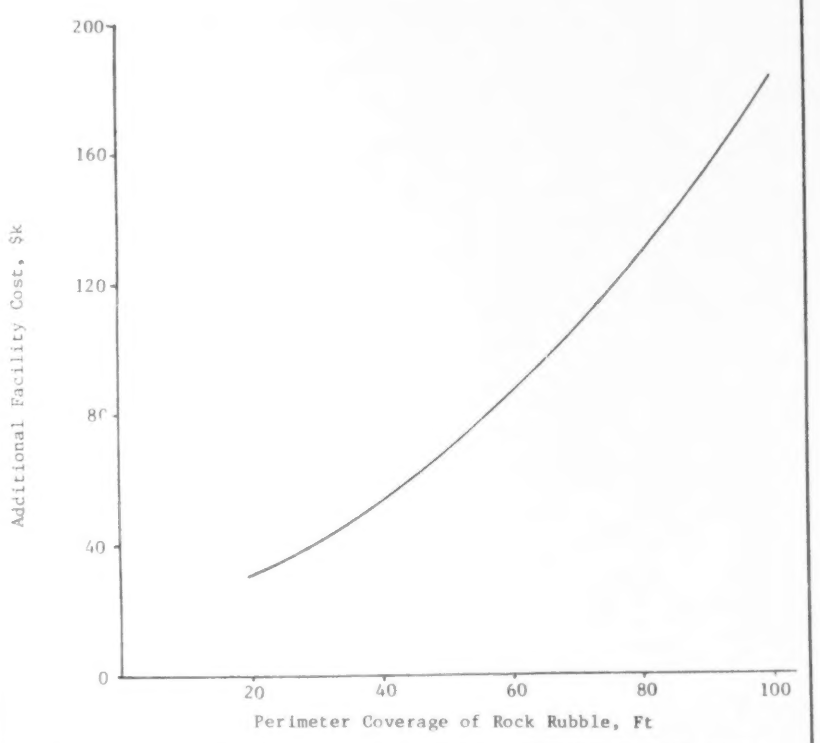

FIGURE E-1. ADDITIONAL FACILITY COST FOR EXTENSION OF ROCK RUBBLE BLANKET.

rock rubble blanket to a greater distance to improve the shelter's resistance to near misses by bombs. Figure E-1 illustrates the additional cost for extending the rock rubble blanket beyond the normal limits for a shelter housing the transportable unit. For example, an additional 20 ft of rock rubble perimeter coverage would cost another $20,000.

FINDINGS

The optimal thickness of the protective soil and rock rubble layer was determined by a series of analyses that considered both a typical rectangular and semicircular shelter cross sections. In Figure E-2, the burial depth is related to the roof thickness and weight of explosives. The roof thickness can be minimized at an 8-ft burial depth because a slight increase in thickness results in a major increase in explosive weight. The protective cover was assumed to contain a rock rubble blanket that would cause the round to detonate at the cover's midpoint. Below 8 ft, the protective layer's weight rather than the explosive weight, would determine the roof thickness. Figure E-3 addresses arch thickness requirements as a function of burial depth for the specified threat. Here again, it appears that an 8-ft burial depth is optimal. This depth therefore was selected as a constant for all structures in this analysis.

In general, member proportions were determined by the blast conditions from a near miss by the specified bomb; however, when the range exceeded 100 ft, the roof thickness was determined by the artillery round impacting on the center of the roof. Range, the perpendicular distance from the structural wall's midpoint to the point of bomb detonation, was varied between 40 and 100 ft in the analysis. At ranges less than 40 ft, member proportions approached or exceeded the practical limits for cast-in-place reinforced concrete. At this point, the failure mode for the shelter would begin to change from ductile to brittle. In addition, cratering effects and the damage that can be caused by ejecta would begin to be a concern. For ranges exceeding 100 ft, there appears to be only a minor change in member proportions as the range increases.

a. Rectangular section. Figure E-4 shows the typical wall designs required to withstand the specified blast conditions. Wall thickness for cast-in-place concrete construction varies from 9 to 37-1/2 in. over the bomb range of interest. Wall thicknesses for the other construction alternatives exceed their practical thickness limitations when the range is less than 50 ft for precast and shotcrete and less than 70 ft for tilt-up construction. The curves appear as dashed lines when the practical thickness limits are exceeded.

b. Double-panel wall section. Composite double-panel wall sections, i.e., elements composed of two concrete panels separated by a sand-filled cavity, have certain characteristics useful to semihardened design for structures located close to a detonation point. However, when the wall thickness was determined for the specified threat, the panel's thickness was governed by the min-

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imum wall thickness requirement rather than structural loading for ranges exceeding 50 ft (Figure E-5). The design was found to be noncompetitive at ranges exceeding 60 ft when compared to cast-in-place concrete. Although it might be competitive at ranges less than 40 ft, this is the region in which cratering and ejecta would dominate.

c. Semicircular arch section. Compared to the rectangular configuration, the semicircular arch section requires more floor space or building volume to provide the needed vertical clearance. Since the rectangular and circular sections use the building volume much more effectively than the semicircular section, the semicircular section was dropped from the list of feasible alternatives.

d. Circular section. Figure E-6 shows the typical wall designs required to withstand the specified threat. In general, the wall thickness for the circular section is less than that required for the rectangular section. In the case of cast-in-place concrete, the wall thickness for the circular section is about 25 to 40 percent less than that for the rectangular section. Similar reductions in wall thickness can be observed for the other construction alternatives. This reduction is attributable to the way in which a circular section resists the imposed loads, i.e., a combination of thrust and bending rather than pure bending.

e. Composite circular section. This consists of a bolted corrugated multiplate circular section covered with fibrous concrete and a cellular foam. The foam would absorb energy from a shock wave and transfer stress uniformly to the composite wall section. It has been assumed that the foam would reduce the blast loading on the composite wall section by about 50 percent. Figure E-7 shows typical thicknesses for fibrous concrete in the composite wall section; these vary from 4 to 15 in.

f. Concrete prefabricated box section. Wall and roof designs for the concrete prefabricated box section were developed using procedures similar to those used for the rectangular section, but with reduced span lengths. Figure E-8 illustrates the wall designs. As expected, the wall and roof thicknesses were substantially less than those for the larger rectangular section. Both thicknesses varied from 6 to 22 in. over the threat range of 40 to 100 ft; however, the curves followed slightly different paths between these two points.

g. Dome section. The wall thickness for the fibrous concrete dome section was determined by the imposed loading and the sections' compressional load-carrying capacity. In addition, it was assumed that the minimum section thickness was 2 in. Figure E-9 illustrates the dome thickness as a function of the blast range. In the 40- to 60-ft range, the curve is approximately linear; thereafter, it approaches the minimum thickness dimension.

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Transportable unit

Construction costs were estimated developed for below-ground shelters for the transportable units using different configurations and conventional cast-in-place concrete construction as well as various construction alternatives described in Section D. Each shelter was designed to withstand the specified threat.

a. Rectangular configuration. Figure E-10 shows construction cost estimates for the transportable unit rectangular shelters for cast-in-place reinforced concrete as well as the shotcrete and precast construction alternatives. Dashed lines appear where the member proportions exceeded the practical wall thickness limits established previously. For conventional cast-in-place concrete, the total facility costs varied from about $540K to $885K, depending on the range. Corresponding unit costs varied from $267 to $438/sq ft. The shotcrete, tilt-up, and conventional precast alternatives have limited ranges of application and, in general, are more expensive than cast-in-place concrete. Although the double-wall panel and segmental precast constructional alternatives can be used over the range of interest, both alternatives appear to be slightly more expensive than the cast-in-place shelter. Local construction experience and site peculiarities may govern the selection of the most economical construction method.

b. Circular configuration. Figure E-11 gives construction cost estimates for the transportable unit circular shelters for cast-in-place reinforced concrete as well as the shotcrete and precast construction alternatives. Dashed lines appear where member proportions exceeded the practical wall thickness limits established previously. For the circular cast-in-place reinforced concrete shelters, the total facility costs varied from about $600K to $1000K, depending on the range. Corresponding unit costs varied from $300 to $500/sq ft, respectively. The composite wall section using foam, fibrous concrete, and corrugated multiplate section and the precast segmental units both were over about 15 percent higher. In general, the other construction alternatives are more expensive than conventional cast-in-place concrete.

Reconstitutional package

Construction costs were estimated for below-ground shelters for the reconstitutional package using procedures similar to those used for the transportable unit. For the rectangular cast-in-place reinforced concrete section, the total facility cost varied from about $400K to $575K as the range decreased from 100 to 40 ft (Figure E-12). The corresponding unit cost varied from about $540 to $777/sq ft, respectively. For the circular cast-in-place reinforced concrete section, the total facility cost varied from about $430K to $630K (Figure E-13). The

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corresponding unit cost varied from $580 to $850/sq ft. These costs are about twice the unit costs for the transportable unit and suggest that hardening the shelters for reconstitutional packages may not be cost-effective for the deployment concept under consideration. Perhaps several reconstitutional packages could be consolidated into a single larger shelter similar in size to the transportable unit shelter to reduce the total facility cost. In general, the other construction alternatives have the same limitation as discussed in the section on transportable unit shelters.

Operational shelters

Construction cost estimates were developed for the operational shelter as (1) a facility integrated with the transportable unit shelter and (2) a stand-alone facility. The integrated facility would be more cost-effective due to savings in concrete and steel when common walls and earthwork are used. First, however, this concept must be established as operationally feasible.

a. Integrated operational and transportable unit shelters. Figure E-14 shows construction cost estimates for the facility with a rectangular section. For cast-in-place reinforced concrete construction, the cost varied from $895K to $1415K. Corresponding unit costs varied from about $166 to $262/sq ft. The combined cost for individual stand-alone facilities varied from 36 to 60 percent more over the same range compared to the integrated facility. The curves' shapes in Figure E-14 are similar to those for the transportable unit with a rectangular section; total cost decreases rapidly as the range increases from 40 to 80 ft.

b. Stand-alone operational shelter. Figure E-15 shows construction cost estimates for a stand-alone rectangular cast-in-place operational shelter with the layout shown in Figure B3-12. The total facility costs varied from $690K to $1010K and the corresponding unit costs varied from about $190 to $280/sq ft.

c. Concrete/prefabricated box section. Construction costs were estimated only for the cast-in-place reinforced concrete construction concept (see Figure E-15). The total facility costs varied from about $685K to $930K. Corresponding unit costs ranged from about $205 to $280/sq ft. Because of the shorter roof and wall spans, the total facility costs were less sensitive to range than the other types. The total facility costs were developed assuming new shipping containers would be used. A substantial cost savings, about $175K to $200K, would be realized if used containers were substituted.

d. Dome section. Figure E-15 shows construction cost estimates for the operational shelter using the dome construction alternative. The total facility costs varied from $560K to $670K over the range. Corresponding unit costs varied from $180 to $220/sq ft, respectively.

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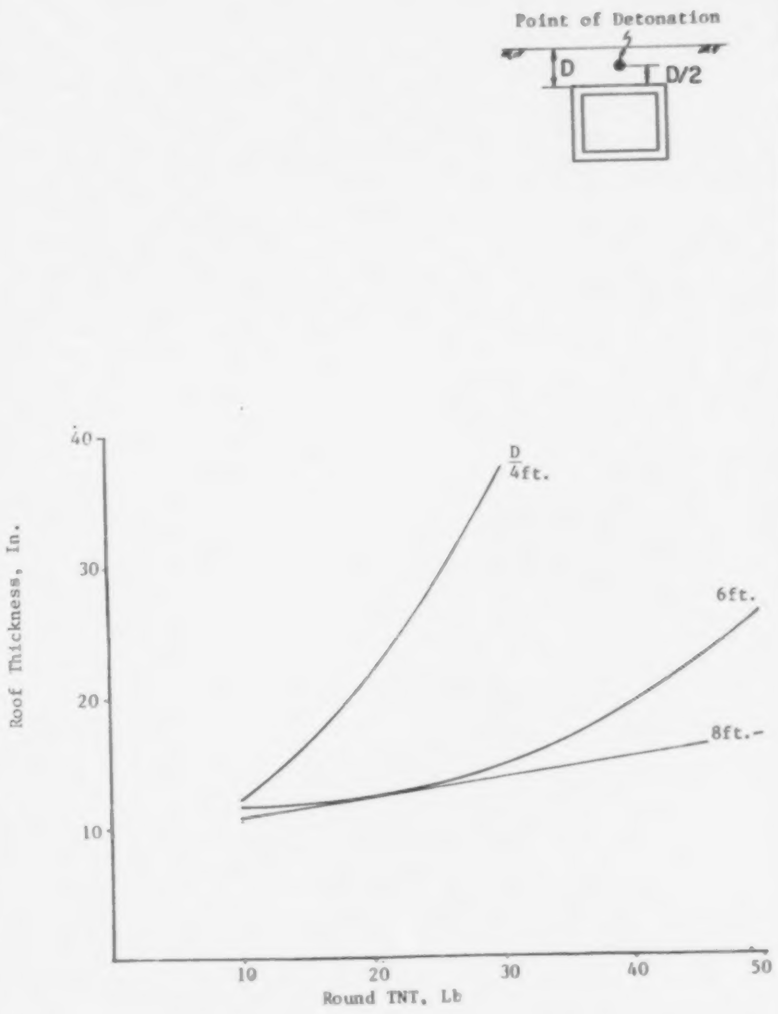

FIGURE E-2. ROOF THICKNESS--COVER RELATIONSHIP (RECTANGULAR).

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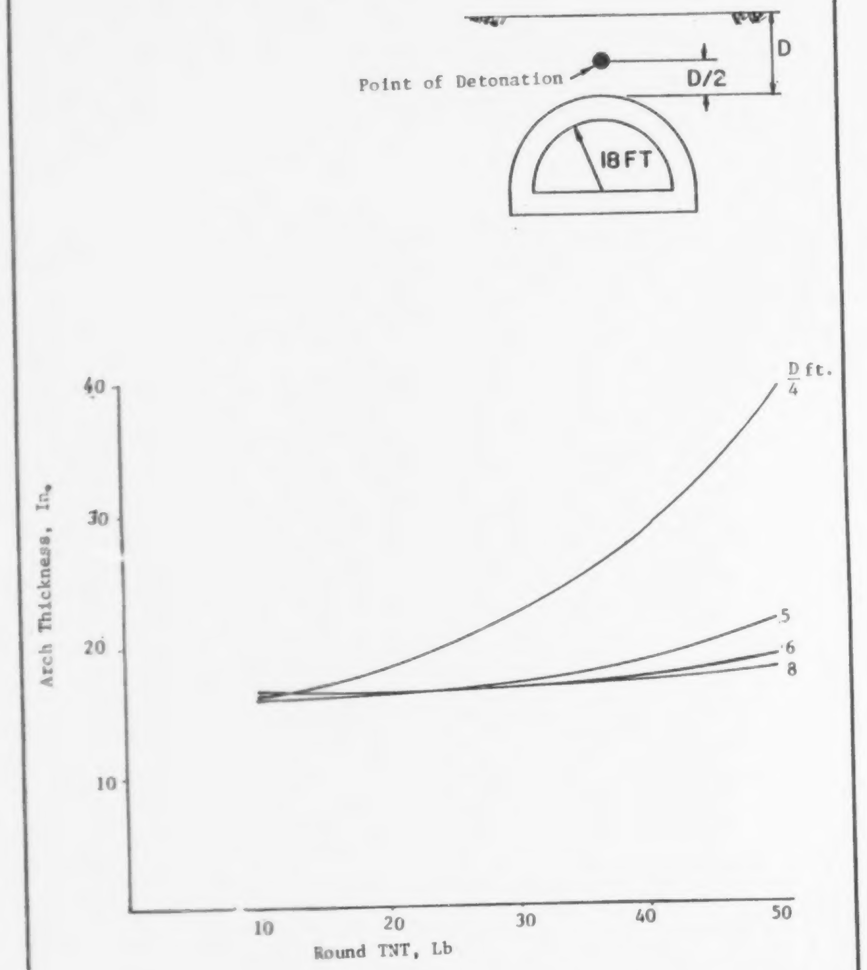

FIGURE E-3. ROOF THICKNESS--COVER RELATIONSHIP (SEMICIRCULAR CROSS SECTION).

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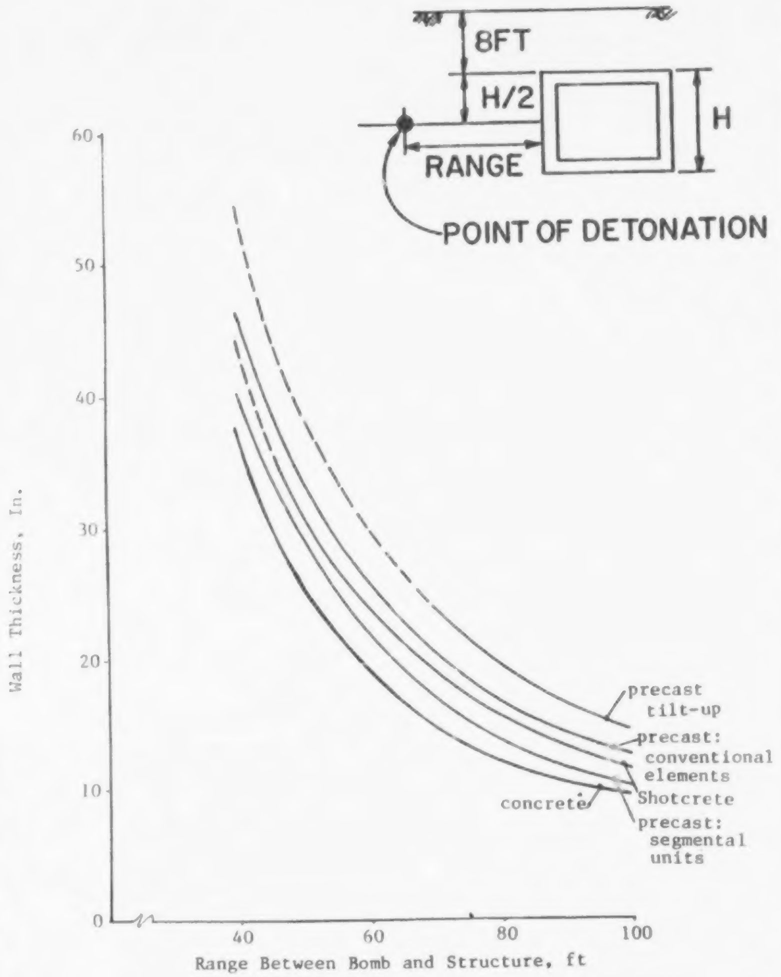

FIGURE E-4. WALL DESIGNS FOR RECTANGULAR SECTION.

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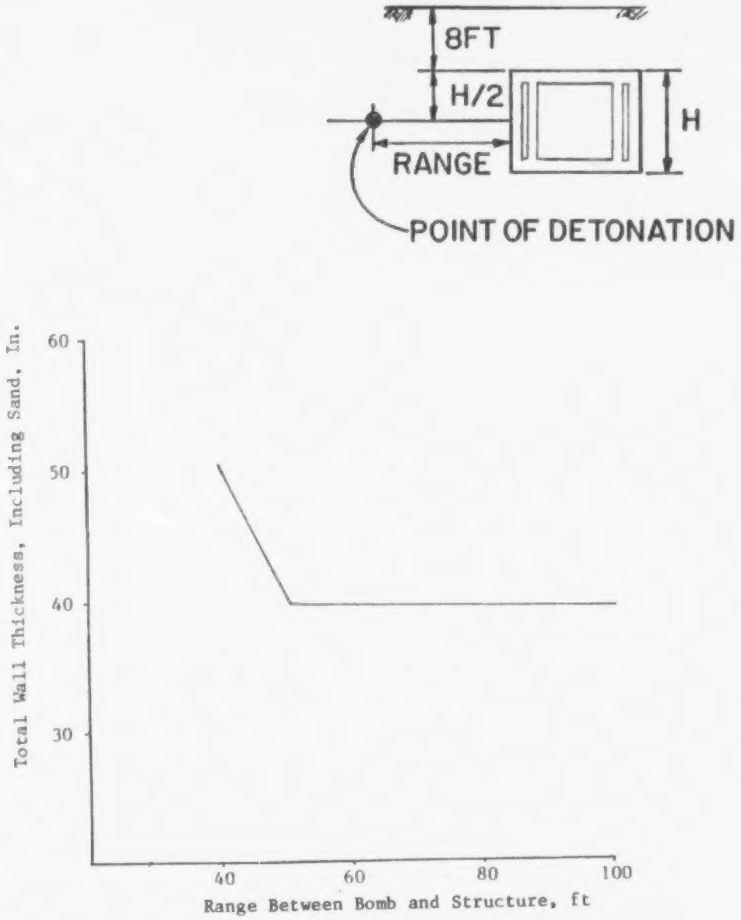

FIGURE E-5. WALL DESIGNS FOR DOUBLE-PANEL WALL SECTION.

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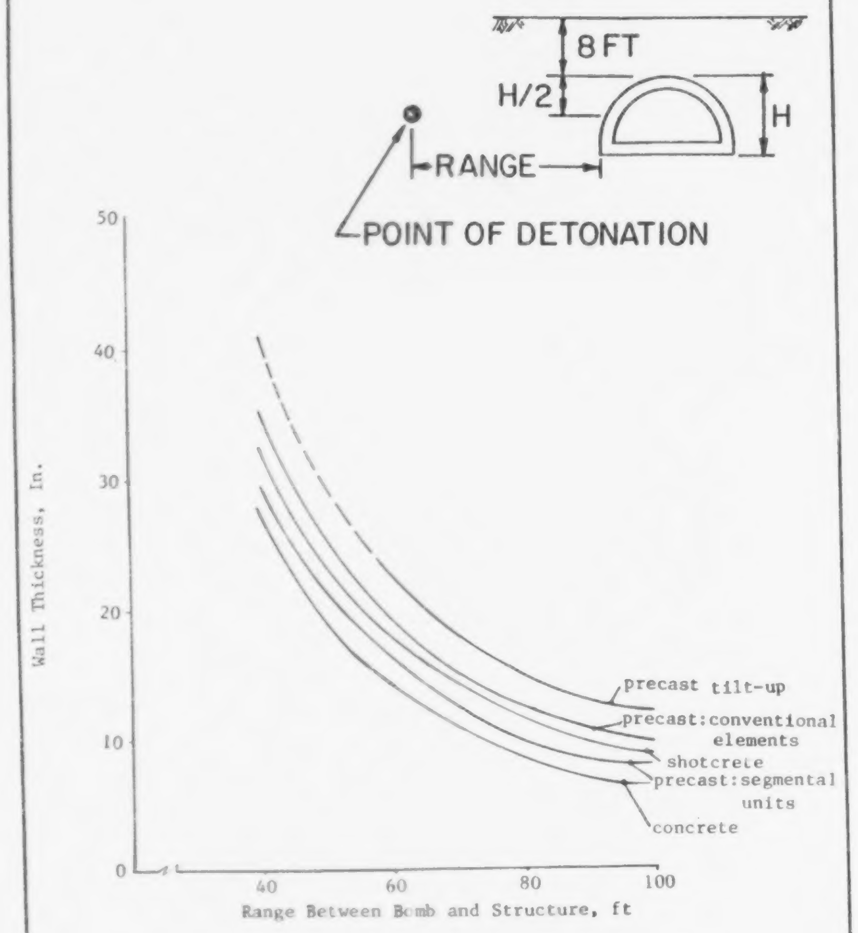

FIGURE E-6. WALL DESIGNS FOR CIRCULAR SECTION.

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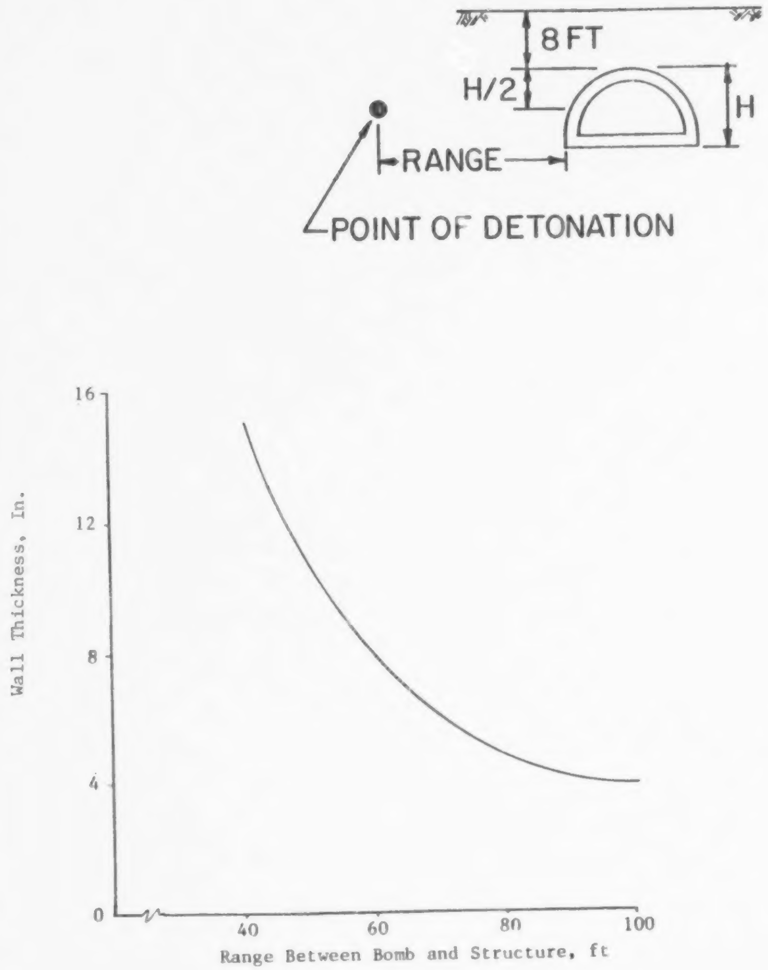

FIGURE E-7. WALL DESIGNS FOR COMPOSITE CIRCULAR SECTION.

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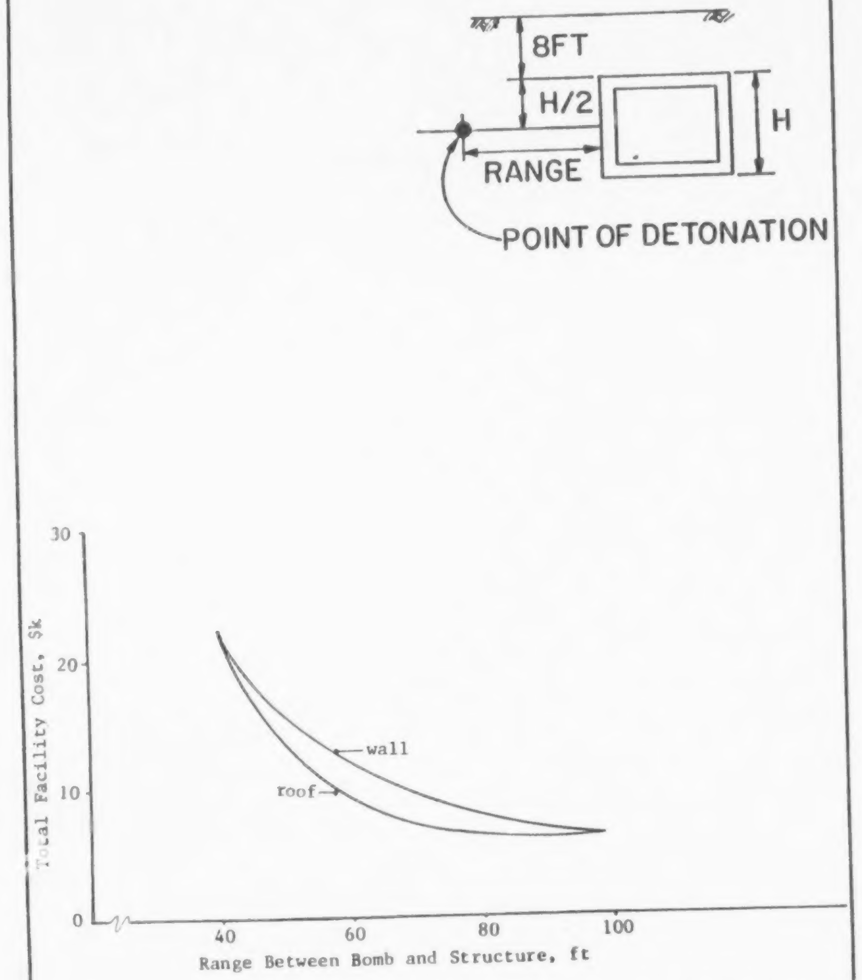

FIGURE E-8. WALL AND ROOF DESIGN FOR CONCRETE/PREFABRICATED BOX SECTION.

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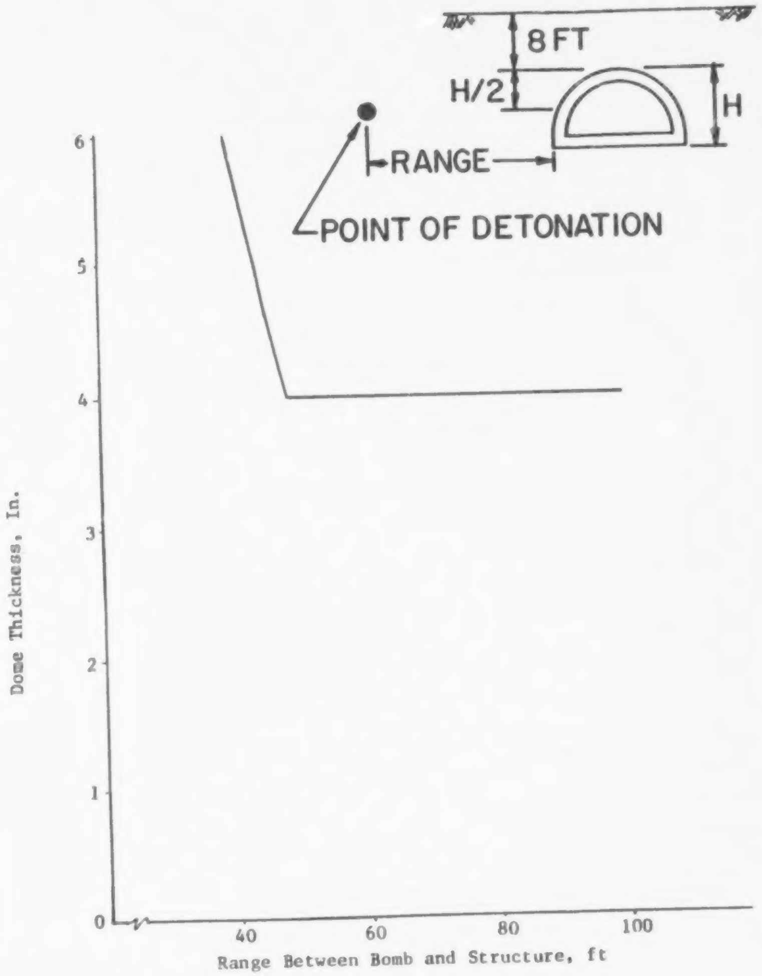

FIGURE E-9. WALL DESIGNS FOR DOME SECTION.

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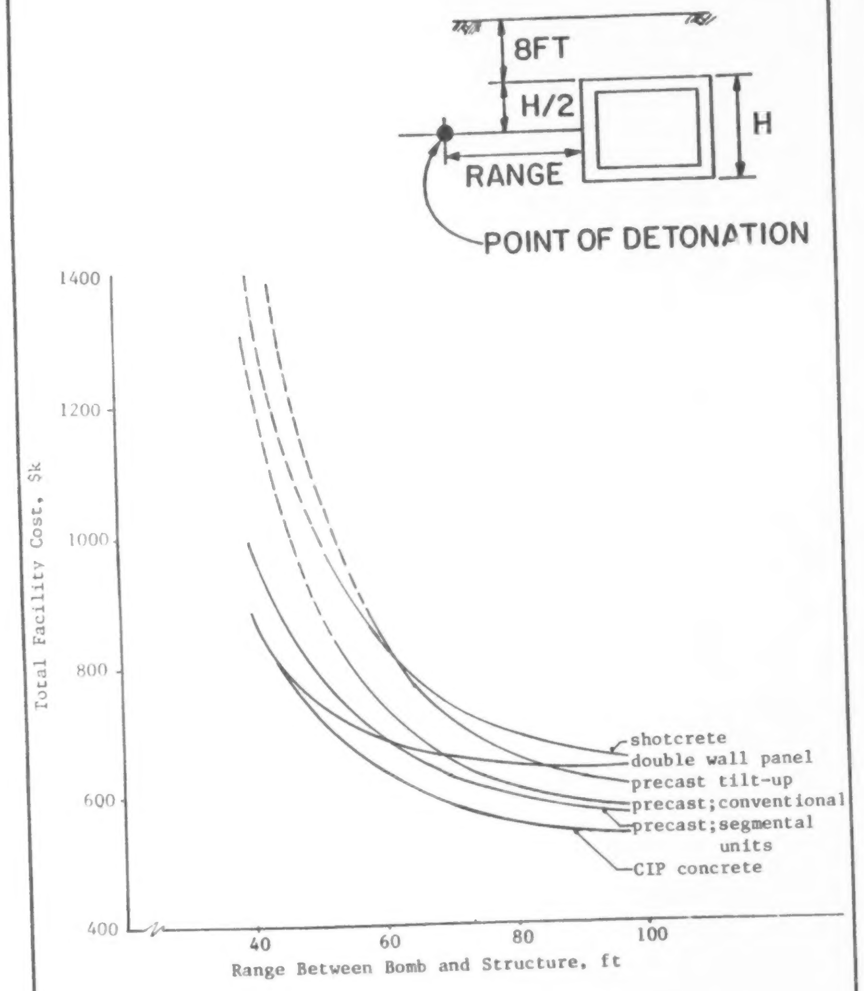

FIGURE E-10. TOTAL FACILITY COSTS FOR TRANSPORTABLE UNIT SHELTER, RECTANGULAR SECTION.

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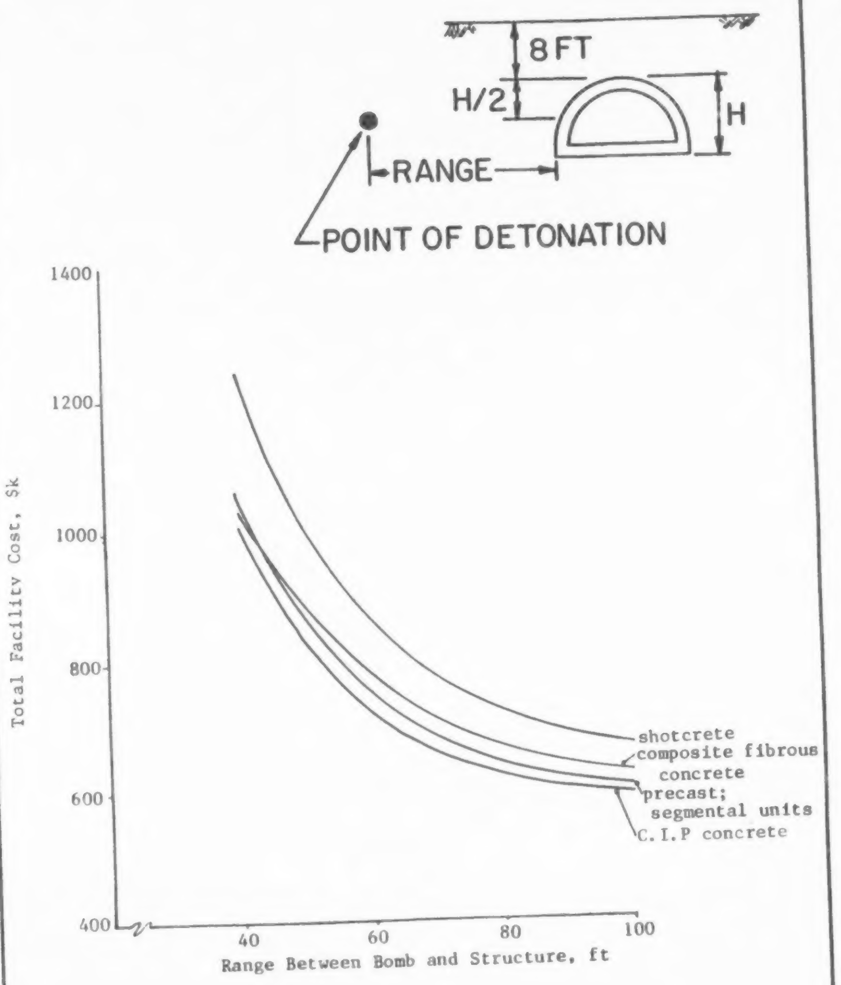

FIGURE E-11. TOTAL FACILITY COSTS FOR TRANSPORTABLE UNIT SHELTER, CIRCULAR SECTION.

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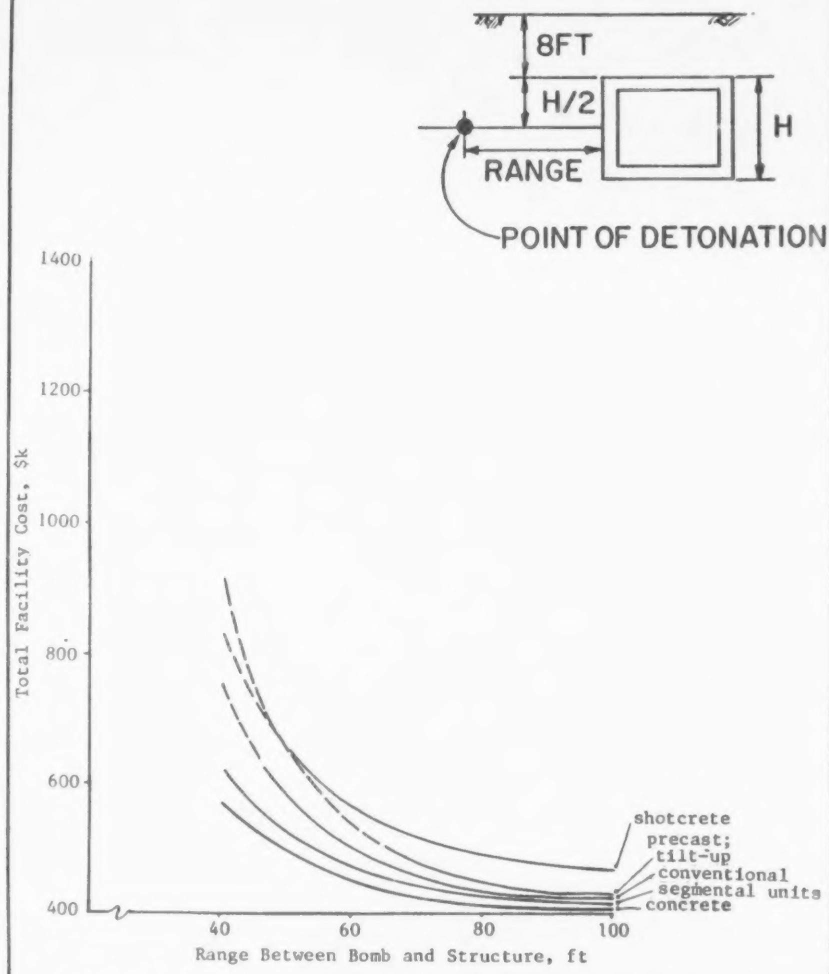

FIGURE E-12. TOTAL FACILITY COSTS FOR RECONSTITUTIONAL PACKAGE SHELTER, RECTANGULAR SECTION.

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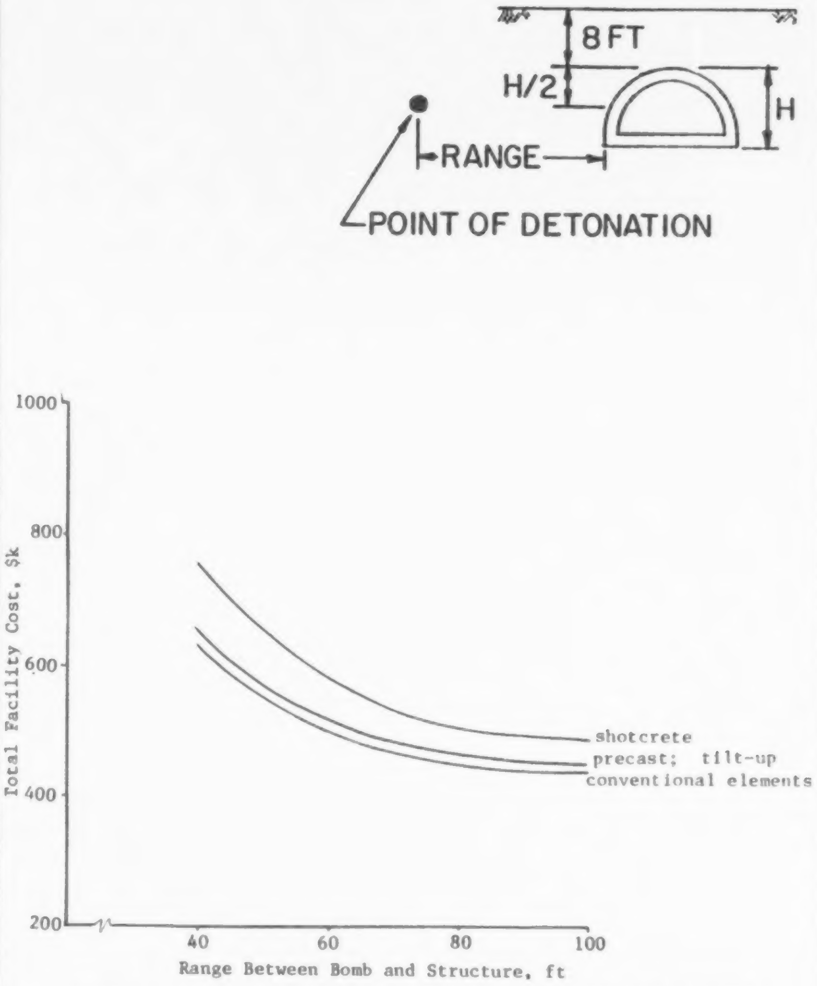

FIGURE E-13. TOTAL FACILITY COSTS FOR RECONSTITUTIONAL PACKAGE SHELTER, CIRCULAR SECTION.

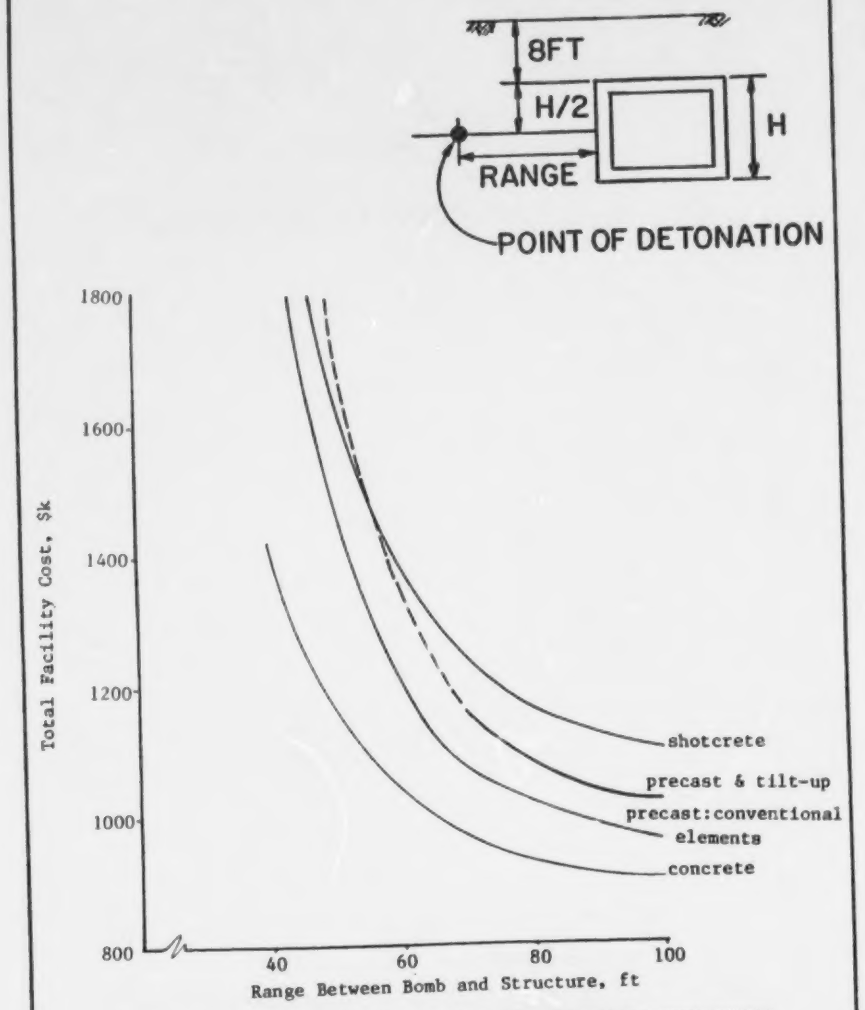

FIGURE E-14. TOTAL FACILITY COSTS FOR INTEGRATED OPERATIONAL AND TRANSPORTABLE UNIT SHELTER.

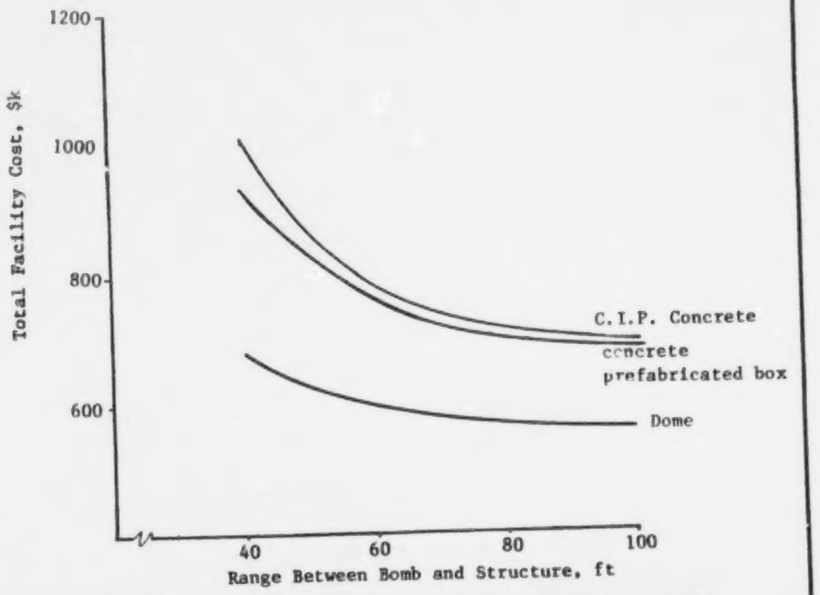

FIGURE E-15. TOTAL FACILITY COSTS FOR OPERATIONAL SHELTER.

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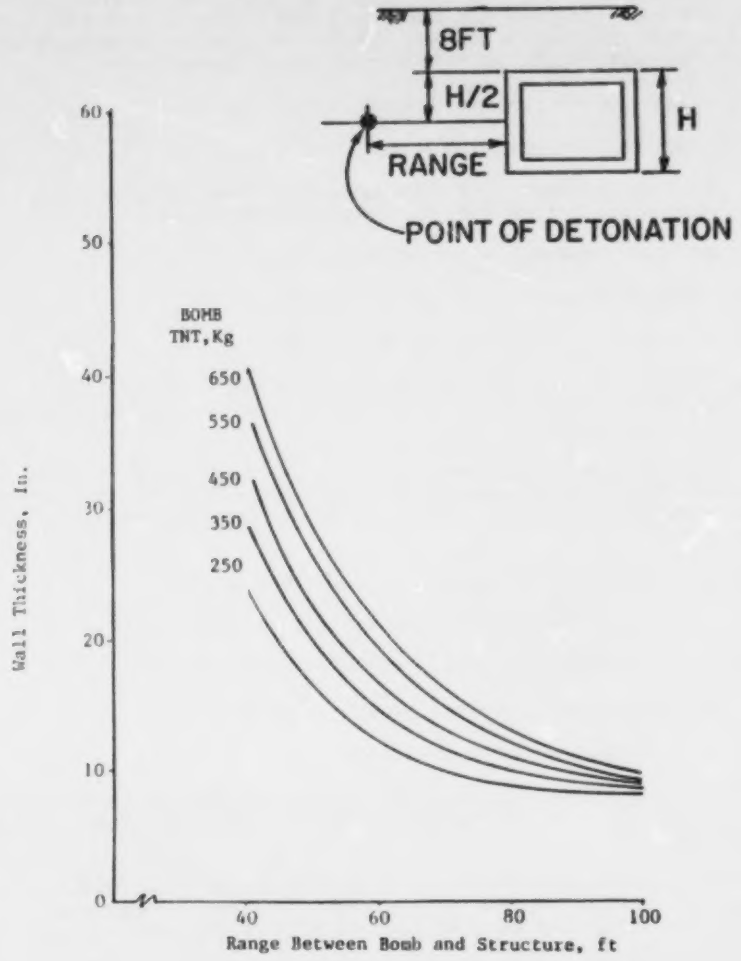

FIGURE E-16. TRANSPORTABLE UNIT SHELTER WALL THICKNESS RELATIVE TO AERIAL ORDNANCE THREAT.

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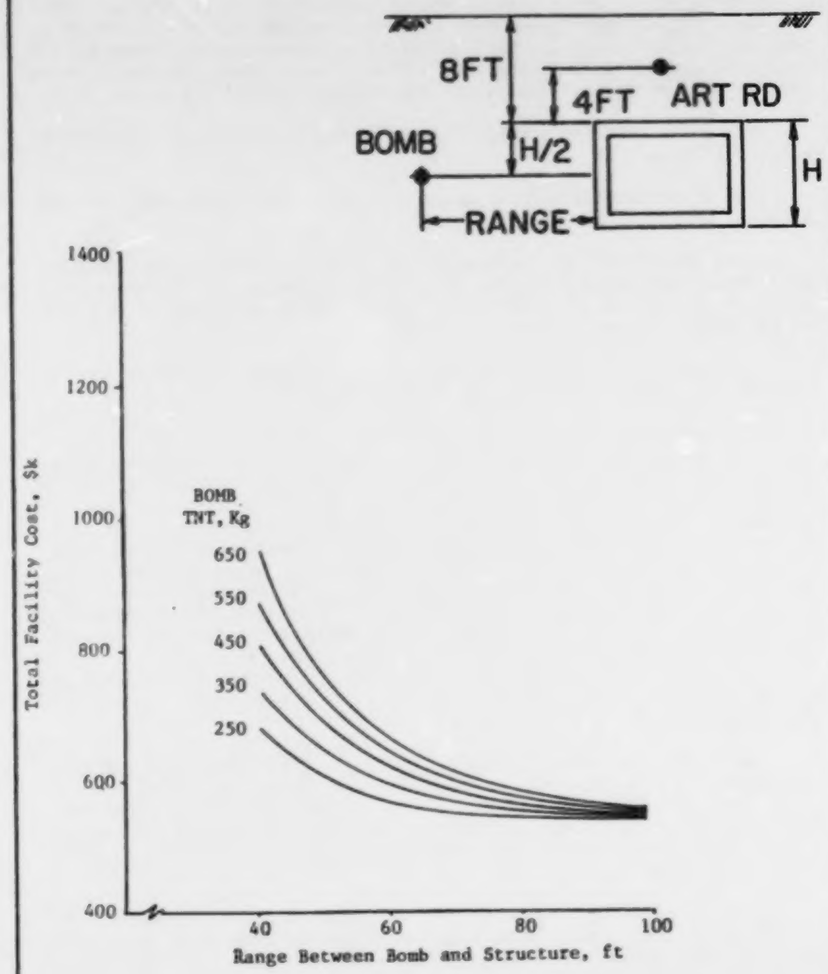

FIGURE E-17. TOTAL FACILITY COST FOR TRANSPORTABLE UNIT SHELTER RELATIVE TO AERIAL ORDNANCE THREAT.

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CONCLUSIONS

The objective of this study was to identify facility configurations and construction techniques that would provide the DCS with alternative ways of constructing shelters to protect prepositioned communication equipment and operational space on installations subject to attack. The desired performance attributes for the proposed facilities were:

Low first cost--no greater than 1.5 times equivalent of nonhardened construction cost.

Rapid construction--no greater than 80 percent equivalent of nonhardened construction time.

Endurance--able to sustain direct hits by heavy armor/concrete piercing ground weapons and near misses by 1.1-ton aerial ordnance without loss of structural integrity or major damage to equipment and loss of personnel located inside.

Low operating cost--energy and maintenance cost no greater than 80 percent equivalent of nonhardened construction.

Two buildings were used to baseline the analysis: a preengineered metal building was taken as the least expensive nonhardened weather shelter available for the stored equipment, and the standard reinforced concrete ammunition storage igloo as the shelter meeting minimum requirements for mounding or burial. The igloo is used primarily to store explosives and to prevent sympathetic detonation of the stored explosives due to accidental detonation of explosives in an adjacent igloo. The igloo is designed to support a minimum earth cover, but significant external dynamic loading. The igloo needed to shelter the transportable unit is about 13.6 times the cost of the metal preengineered building; the ratio for the reconstitutional unit storage is about 22.4. This cost increase does bring slightly more protection than can be provided by the metal building; however, it adds little protection against the specified threat.

The standard igloo was assumed to be the baseline for comparative estimates. It is basically nonhardened and incorporates the mounding used in all of the alternatives. The cost limit for the transportable unit shelter would be about $1215K and about $770K for the reconstitutional unit shelter using the factor of 3 given in the desired performance attributes.

Several building configurations and construction techniques were investigated that would satisfy all four performance attributes. All shelters considered were designed to withstand the specified threat which would allow the 1.1-ton bomb to detonate as close as 40 ft from the exterior wall at a penetration depth equal to the wall's centerline, and to survive direct hits to the roof from 8-in. artillery rounds. If the bomb detonates closer than 40 ft, the shelter could be damaged by cratering action or by flying ejecta. Superhard structures would be required to withstand this more severe threat.

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The transportable unit shelter can be constructed to withstand the 40-ft standoff distance for $885K to $1060K, about 2.19 to 2.62 times the cost of the baseline shelter. Shelters meeting the performance criteria are partially buried facilities of the following types:

- Cast-in-place concrete rectangular cross section
- Cast-in-place concrete circular cross section
- Fibrous concrete, insulating foam, and corrugated metal plate composite construction in a circular cross section
- Precast segmental units, rectangular cross section
- Precast segmental units, circular cross section
- Double wall panel, rectangular cross section.

The composite construction approach could be constructed fastest since it does not require forms to be erected and removed or walls to be constructed using lifts.

The reconstitutional unit shelter can be constructed for $575K to $760K or 2.24 to 2.92 times the baseline shelter. The shelters meeting the performance criteria are partially buried facilities of the following types:

- Cast-in-place concrete rectangular cross section
- Cast-in-place concrete circular cross section
- Precast segmental units, rectangular cross section
- Precast segmental units, circular cross section
- Shotcrete circular cross section

The rectangular cross sectional shelter could be constructed fastest since it would use standard forms and conventional construction techniques.

The operational shelters can be constructed for $650K to $1415K or 1.11 to 2.43 times baseline facility cost. Shelters meeting the performance criteria are partially buried facilities of the following types:

- Cast-in-place concrete integrated with the transportable unit storage in the rectangular cross section
- Cast-in-place concrete rectangular cross section
- Concrete/prefabricated box form construction
- Dome construction

guidance

The concrete/prefabricated box form probably could be constructed fastest since it does not require special equipment or unique skills. However, there should be very little difference in construction times between the box forms and the dome.

All other configurations and construction techniques were found to be much more expensive than the alternatives selected above when designed to survive the defined threat.

All shelter concepts were designed to meet the low operating cost criteria by incorporating the following features:

1. Environmental control systems were designed on the basis that buried/mounded shelter interiors will be maintained at a constant ground temperature.
2. In the operational shelters, a chiller using well water as the cooling fluid will be installed rather than other cooling techniques that could require more equipment and maintenance.
3. The ventilation system for the operational shelter will be protected completely with a blast valve and can control the interior environment using outside air without use of the chiller. This system can be used when outside conditions permit. Under conditions that require CBR filtering, the blast-valve-protected ventilation system can draw 375 cfm into the cooling system to reduce the demand on the cooling system and to change the air in the shelter.
4. The mechanical and electrical systems will be very simple, requiring only basic controls.
5. The fuel storage tank will be elevated above the generators to eliminate the need for pumps and related equipment.
6. Waste will be discharged through a lift station, which is located in the mechanical room to make it easily accessible for maintenance.
7. The mechanical room floor in the operational shelter will be placed at the same level as the adjoining shelter floor to simplify equipment movement and maintenance.
8. Equipment storage shelter floors will be sloped to drain to the outside and provided with two depressed tracks to help guide vehicles as they are backed into the shelter.

Selection of the appropriate shelter concepts and construction techniques to be further investigated for design consideration at a specific geographical location is strictly the planners' responsibility. Enough comparative data have been provided, however, to assist planners in determining approximate construction cost or the impact of changing the assumptions underlying the cost estimates presented.

guidance

All power generation operations were moved outside sheltered areas to eliminate the need for high-maintenance, semihardened air intake and exhaust structures and for removing the resulting waste heat from the building. This provides the flexibility to perform maintenance on the portable generators either in place or at a remote maintenance shop.

Power generators were not included in the transportable unit and reconstitutional unit shelters. To reduce cost and maintenance requirements, it was assumed that the crews responsible for opening the shelters and removing the stored equipment would use portable generators. Using this technique, one portable generator set could be used to open all the shelters on an installation.

TABLE E-1

COST GROWTH FACTOR (CGF)

$$\text{CGF} = \frac{\text{Raw Inflation Index for Midpoint of Construction}}{\text{Raw Inflation Index for Midpoint of the Cost Estimate to be Adjusted}}$$

MONTHLY RAW INFLATION INDICES FOR MILITARY CONSTRUCTION
BASED ON OSD* RAW INFLATION RATES
BASE PERIOD 1983 : 10

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
80	.749	.750	.753	.758	.760	.765	.775	.783	.792	.804	.809	.810
81	.811	.812	.814	.819	.821	.825	.838	.848	.858	.873	.879	.879
82	.881	.882	.885	.890	.892	.897	.903	.917	.926	.939	.945	.945
83	.947	.947	.950	.955	.956	.961	.971	.979	.988	1.000	1.005	1.005
84	1.007	1.007	1.010	1.014	1.016	1.020	1.029	1.037	1.045	1.057	1.061	1.062
85	1.063	1.063	1.066	1.070	1.071	1.075	1.084	1.092	1.100	1.111	1.115	1.115
86	1.117	1.117	1.119	1.123	1.125	1.129	1.130	1.146	1.155	1.166	1.171	1.171
87	1.172	1.173	1.175	1.179	1.181	1.185	1.195	1.204	1.213	1.224	1.229	1.230
88	1.231	1.232	1.234	1.238	1.240	1.245	1.255	1.264	1.273	1.286	1.291	1.291
89	1.293	1.293	1.296	1.300	1.302	1.307	1.318	1.327	1.337	1.350	1.355	1.356
90	1.357	1.358	1.361	1.365	1.367	1.373	1.384	1.393	1.404	1.417	1.423	1.424

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*OSD = Office of the Secretary of Defense.

TABLE E-2

AREA CONSUMPTION FACTOR (ACF) AND EXCHANGE RATE ASSUMPTIONS*

A. ACF=1.0 (Washington, DC)

B. Exchange Rates are AD/LEEEC forecasts for FY 83. When official exchange rates for the FY 83 MCP become available in late summer, AF/LEEEC will adjust MAJCOM prices accordingly.

CONUS

LOCATION	FACTOR
ALABAMA	89
Gulf Coast Area	1.00
ALASKA	1.40
Aleutian Islands	3.80
Campion	3.00
Cape Lisburne	3.50
Cape Newenham	3.20
Cape Romanzof	3.20
Clear AFS	2.20
Cold Bay	3.00
Dew Stations	3.80
Eielson AFB	2.10
Elmendorf AFB	1.90
Ft Greely (Big Delta	2.20
Ft Richardson	1.90
Ft Wainwright	2.10
Ft Whittier	2.10
Ft Yukon	3.00
Galena	3.00
King Salmon Airport	2.60
Kodiak	2.50
Kotzebue	3.50
Murphy Dome	2.10
Nome	2.30
Point Barrow	3.50
Sparrevohn	3.50
Tatalina	3.50
Tin City	3.20
	Scott AFB
ARIZONA	1.01
Davis-Monthan AFB	1.10
Ft Huachuca	1.20
Gila Bend AFS	1.15
Yuma P.G	1.10

CONUS cont'd

LOCATION	FACTOR
ARKANSAS	.87
CALIFORNIA	1.11
Beale AFB	1.15
Castle AFB	1.15
Desert Areas	1.20
Edwards AFB	1.20
George AFB	1.20
March AFB	1.15
Mather AFB	1.15
McClellan AFB	1.15
Norton AFB	1.15
San Francisco Bay Area	1.20
Sierra Army Depot	1.20
Travis AFB	1.20
Vandenberg AFB	1.20
	Ft Richie
COLORADO	.98
Buckley ANGB	.98
Denver	1.10
CONNECTICUT	1.03
New London	1.20
DELEWARE	.99
DISTRICT OF COLUMBIA	1.00
FLORIDA	.95
Cape Canaveral AFS	1.15
Gulf Coast	1.00
Key West	1.20
Miama	1.15
Patrick AFB	1.15

LOCATION	FACTOR
GEORGIA	.86
Atlanta	1.00
Ft Stewart	1.02
King's Bay	1.02
HAWAII	1.20
Kauai	1.80
IDAHO	.96
Mt Home AFB	1.20
ILLINOIS	1.04
Glenview	1.06
Granite City Army Depot	1.20
Great Lakes	1.06
....	1.20
INDIANA	.97
Gary	1.05
Grissom AFB	1.10
Indianapolis	1.05
IOWA	.97
KANSAS	.96
KENTUCKY	.94
LOUISIANA	.92
England AFB	1.05
Ft Polk	1.05
New Orleans	1.10
MAINE	.90
Northern Area	1.14

HQ USAF ANNUAL CONSTRUCTION PRICING GUIDE FOR FY 83 THRU 87 PROGRAMS AS OF MAR 81.

TABLE E-2, CONT'D

CONUS cont'd

LOCATION	FACTOR
MARYLAND	.96
Area Adjacdent to DC	1.00
....	1.10
Patuxent River ATC	1.10
MICHIGAN	1.02
Northern Area	1.15
MINNESOTA	.99
MISSISSIPPI	.99
Keesler AFB	1.00
Mississippi AAP	1.00
OREGON	
MISSOURI	.98
Ft Leonard Wood	1.20
St Louis	1.02
StLouis AAP	1.02
MONTANA	.95
Malstrom AFB	1.15
Northern Area	1.15
Ellsworth AFB	
NEBRASKA	.94
TENNESSEE	
NEVADA	1.05
Fallon NAS	1.20
Nellis AFB	1.15
Tonopah	1.60
Dallas	
NEW HAMPSHIRE	.92
Portsmith	.97
Dugway Proving Ground	

LOCATION	FACTOR
NEW JERSEY	1.04
NEW MEXICO	.96
Holloman AFB	1.05
NEW YORK	1.03
Griffiss AFB	1.06
Hancock Fld	1.06
Long Island	1.17
New York City	1.17
Plattsburg AFB	1.06
US Military Academy	1.17
Puget Sound Area	
NORTH CAROLINA	.84
Camp Lejeune	.95
Cherry Point	.95
Ft Bragg	1.00
Pope AFB	1.00
Seymour Johnson AFB	1.00
NORTH DAKOTA	.91
Northern Area	1.15
OHIO	1.02
OKLAHOMA	.94
Tinker AFB	1.00
....	1.01
PENNSYLVANIA	1.01
RHODE ISLAND	1.00
SOUTH CAROLINA	1.00

LOCATION	FACTOR
SOUTH DAKOTA	.92
....	1.15
....	.88
NAS MEMPHIS	1.00
TEXAS	.98
Carswell AFB	1.10
....	1.10
UTAH	.98
....	1.30
Hill AFB	1.20
VERMONT	.91
Northern Area	1.07
VIRGINIA	.91
Area adjacent to DC	1.00
Dahlgren	1.00
Ft Lee	1.00
Norfolk-Newport News Area	1.00
WASHINGTON STATE	1.01
....	1.15
WEST VIRGINIA	.96
WISCONSIN	.98
WYOMING	.91

TABLE E-2, CONT'D

UNITED STATES JURISDICTIONS

LOCATION	FACTOR
CANAL ZONE	1.50
CAROLINA ISLANDS	
Truk	2.00
JOHNSTON ISLANDS	2.40
LINE ISLANDS	
Paymyra	2.00
MARIANA ISLANDS (GUAM)	2.00
MARSHALL ISLANDS	
Bikini	2.40
Eniwetok	2.40

LOCATION	FACTOR
Kwajalein	2.40
Majuro	2.40
Meck	2.40
MIDWAY ISLAND	2.40
PUERTO RICO	
Roosevelt Roads Area	1.50
SAN JUAN AREA	1.50
SAMOA	2.40
VIRGIN ISLANDS	1.30
WAKE ISLAND	2.20

OVERSEAS

LOCATION	FACTOR
ADMIRALTY ISLANDS	2.20
ALGERIA	1.30
ARGENTINA	1.90
ASCENSION ISLAND	2.50
AUSTRALIA	
North Coastal Areas	2.30
South Coastal Areas	1.10
AZORES	1.30
(ER = 55.00 Escudo/US $)	
BAHAMA ISLANDS	1.50
BELGIUM	1.50
(ER = 35.00 Franc/US $)	
BERMUDA	1.60
BOLIVIA	1.70
BRAZIL	1.50
BRITISH GUIANA	1.20
BRITISH HONDURAS	1.00
BRITISH WEST INDIES	
Antigus	1.40
Barbados	1.20
Trinidad	1.20
BURMA	1.40
CANADA	
(ER = 1.15 Dollar/US $)	
Labrador	1.40
Newfoundland	
Argentia	1.80
Inland Areas	2.20
North Inland Areas	
(Dew Line)	4.20
South Inland Areas	1.60
CHILI	1.50
CHRISTMAS ISLANDS	2.20
COLUMBIA	1.30

LOCATION	FACTOR
COSTA RICA	1.00
CUBA	
Guantanmo Bay	1.60
DENMARK	1.30
(ER = 6.50 Kroner/US $)	
DIEGO GARCIA	3.00
ECUADOR	1.50
EGYPT	1.50
(ER = 0.7 Pounds/US $)	
EL SAVADOR	1.00
FRENCH GUIANA	1.20
GERMANY, WEST	1.60
(ER = 2.00 Mark/US $)	
GREECE	1.40
GREENLAND	
Ice Cap	4.00
Narsarssuak	4.20
Sondrestrom AFB	3.10
GUATEMALA	1.00
ICELAND	3.00
INDIA	
Bombay	.90
ISRAEL	1.50
(ER = 8.6 Shekel/US $)	
US Labor	1.50
Local Labor	1.10
ITALY	
(ER = 1,000.00 Lira/US $)	
Northern	1.30
Southern (Naples)	1.10
JAMAICA	1.20

TABLE E-2, CONT'D

LOCATION	FACTOR
JAPAN	
(ER = 200.00 Yen/US $)	
Northern Area	1.70
Okinawa	1.60
Southern Area	1.60
Wakkanai	1.80
KOREA	1.05
(ER = 650.00 Won/US $)	
LIBERIA	.80
MEXICO	
Mexico City	1.00
MOROCCO	1.00
NETHERLANDS	1.60
(ER = 2.00 Guilder/US $)	
NEW ZEALAND	.80
NICARAGUA	1.00
NORWAY	1.40
OMAN	2.25
PAKISTAN	
West Karachi	1.20
PARAGUAY	1.60
PHILIPPINE ISLANDS	1.00
(ER = 7.50 Peso/US $)	
PHOENIX ISLANDS	
Canton Island	2.40
SAUDI ARABIA	
Dhahran	2.25
SPAIN	1.30
(ER = 85.00 Pesatas/US $)	
SRI LANKA	1.10
SWEDEN	1.20
THAILAND	1.00
TURKEY	1.60
(ER = 74.00 Lira/US $)	
UNITED KINGDOM	1.50
(ER = .43 Pounds/US $)	
URUGUAY	1.60
VENEZUELA	1.30
Thule	3.50

SECTION F CASE STUDY

CASE STUDY

function

To provide a semihardened shelter for an AUTODIN facility that can maintain operations in areas subject to attack using the design concepts developed in Section D.

policy/sop

policy/sop

1. The facility will provide the same functional spaces as now designed into unhardened AUTODIN facilities. Maximum facility population is estimated at 30.
2. Site security will be external to the facility and installed/monitored by others. Space will be provided for security and access control.
3. The facility will be able to operate on a continuous, uninterruptible basis without external support for at least 96 hours.
4. The design, siting, and construction of external facilities are not to be considered in this study.
5. The facility should provide for the command and communication circuits from the unhardened communication center as well as needed circuits to the remote facilities.
6. The base power supply will be the primary source for the facility. A hardened uninterruptable power source (UPS) will be provided for temporary backup and portable generator sets will be provided for permanent backup.

issues and assumptions

1. Siting

Facilities should be located away from primary targets (e.g., aircraft, runways, weapon systems, ammunition dumps) to reduce the possibility of collateral damage from an attack. It has been assumed that the facility is not a prime target and will be subjected only to bombs intended for other targets. The facility can be located on- or off-post as needed to provide adequate separation from prime targets. If located off-post, the cost of providing and maintaining perimeter security must be considered in planning.

Shelter concealment has not been considered since construction can be observed easily by satellite.

Depending on the terrain, the facility can be constructed either on the surface and mounded, partially buried and mounded, or totally buried. If possible, the facility should be sited to provide an entrance sloping away from the facility. Advantage should be taken of the natural contour of the land. Foundation drainage is required to control groundwater.

2. Facility configuration

The facility has been designed using two of the alternatives discussed in Section D: (a) the rectangular shape with longitudinal interior load bearing walls and short roof spans and (b) interconnected hemispherical domes. Floor elevations in both configurations will be constant. Structural slabs below each raised floor area will be depressed to provide adequate plenum volume and will be sloped for drainage.

Blast doors for personnel and equipment movement will be designed to withstand overpressure and debris from the specified threat. These horizontal sliding doors will be protected in structural concrete pockets and will be operated electrically. The roofline will be extended to protect the doors from direct hits and to provide weather protection for the portable generators sets in their operating positions. The blast doors' design will consider the reflected effect of a blast within the enclosed area.

Interior fire-rated doors will be used to isolate areas of the facility for fire and smoke control.

Vents with fire dampers will be provided in the load bearing walls as needed to promote air circulation. Air will be exhausted to the exterior through a blast valve.

Uncovered concrete floors will be treated with a sealant to reduce dust, and vinyl floor covering will be provided in all other areas. The raised floor will be designed for computer room applications and expected loads. A dropped ceiling will be used in the rectangular configuration to cover the overhead air handling units, chilled-water lines, and ductwork. In the dome configuration, air handling units will be mounted in vertical shafts located in the center of each dome. Chilled-water lines will be placed under the floor.

issues and assumptions

Exterior wall and roof surfaces will be waterproofed with a sprayed-on material or single-ply membrane and covered with insulation board before backfilling.

3. Access

Personnel access to the facility will be through the security control area. Decontamination of personnel entering the facility was not a design consideration. Two emergency exits to grade have been provided.

The emergency exits will be placed as shown in Figures F-1 and F-2 to take advantage of two structural walls' intersection. Each exit will consist of a tube extending to the surface, filled with sand to ensure continuity of the protective layer over the facility. To use the exit, personnel will release the lower door, allowing the sand to fall into the facility, climb up the ladder in the tube, and release the weather cap at the surface. Two wall-hung ladders will be provided to allow personnel to release the inner door from one side to avoid the load of falling sand.

4. Electrical power

The facility will require power for operations and environmental control. The base power system will be the facility's main power source. A rotary UPS will be used to ensure power availability over short periods of interruption. During an attack, all operations would cease and battery-operated emergency lights would provide illumination after the base power is lost. After an attack, operations would begin again once the portable generators are moved outside and brought online. The generators, stored in the mechanical room, would be moved to their exterior operating spaces, connected to the fuel and power supply lines, and put into operation.

The estimated power requirement is 400 kW based on the 177-kW load criteria plus the environmental control system. This requirement can best be met by two 200-kW portable diesel generator sets. A buried fuel storage tank with a 6000-gal capacity will provide for 7 days of continuous operations.

5. Environmental control

Operational cooling will be provided by a 50-ton groundwater-cooled chiller, a chilled-water distribution system, and a distributed system of air handling units. Water will be taken from one well, passed through the chiller and returned to the ground through a second well. Two wells will provide a more reliable water source for the facility and, in case of pumping problems, cooling water could be wasted to the sewage lagoon or just to the outside.

issues and assumptions

The mechanical equipment room will have an air handling unit (AHU) and distribution system for meeting low cooling loads and distributing outside air throughout the operational space. Chilled water AHUs will be located above the dropped ceilings or in the vertical shafts in the operational spaces to carry the rest of the load. Distributed AHUs could be floor-mounted if space were available. The AHUs can be used to meet the cooling requirements efficiently as the loads vary.

Outside air will be ducted into the facility at 450 cfm through a blast valve and CBR filter. This approach will produce a positive pressure in the facility, which will reduce infusion of contaminants from the outside. To reduce operating costs, an outside air system rated at 10,000 cfm will be provided for economic cooling when conditions permit. This system uses a blast valve for drawing in outside air, but does not have a CBR filter. The air will be exhausted by a pressure differential through the blast valve.

The mechanical equipment room contains one AHU with a CBR filter, chiller, chilled-water circulation pumps, compressor for control systems, and a sanitary sewage lift station.

6. Water and waste disposal

Water will be supplied from a ground well and pressure tank to meet both potable and cooling water requirements. Cooling water will be returned to the ground through a second well. Two wells will ensure a secondary water source in case of a failure in the primary system. Cooling water will be wasted to the outside through the wastewater system if it is not possible to return it to the ground through one of the wells.

Wastewater will be discharged into the sewage lagoon through the lift station located in the mechanical room. The facility's successful operation depends on the ability to discharge waste. Therefore the lift station will be placed inside the shelter for protection. (An unprotected lift station located near the lagoon would require the gravity pipe to be buried deeply.) After an attack, if the discharge pipe is blocked (damaged or destroyed), the lift station can be used to pump waste to the surface through a flexible hose. The lagoon will be designed based on the expected wastewater flow. If cooling water is discharged through the system, the lagoon will be allowed to overflow until system problems can be solved.

Flexible connections will be used in the piping systems near the facility to reduce possible damage from ground shock.

7. Security

It has been assumed that project planners will satisfy site security requirements and, thus, this information has not been considered here. Security personnel will provide interior security. Space will be provided in the facility for an access control station. A small, secure space has been provided to store a few incendiary devices for destroying classified documents.

activities

1. Establishing workstations.
2. Installing communication equipment initially, including integration and checkout.
3. Filling water and fuel storage tanks.
4. Checking backup power.
5. Testing environmental control equipment.
6. Monitoring internal environment and status of storage tanks.
7. Performing periodic operational checks.
8. Maintaining equipment.
9. Charging and maintaining UPS batteries.

personnel

1. Equipment installers.
2. DEH personnel to fill and maintain the storage tanks.
3. Inventory personnel.
4. Equipment test, operation, and evaluation personnel.
5. DEH building equipment maintenance personnel.

equipment

1. Heating, ventilation, and A/C equipment.
2. Temperature and humidity sensors and controls.
3. Communication equipment.
4. Portable electronic testing equipment on movable carts.
5. Fire alarms and sensors.
6. Security system components.
7. Water pumps and supply equipment.
8. Sanitary lift station.
9. Fuel storage tank and distribution.

activities

personnel

equipment

requirements	criteria	commentary
1. Adequate space.	1. Size facility to provide space equal to that shown on the DCA-furnished layout drawings for an AUTODIN switch. There are no requirements for living quarters, rest areas, food storage/preparation, or general storage.	
2. Structure.	2. Semiharden facility to withstand overpressures due to blasts from near misses by bombs exploding at ranges of 75 ft or more.	
3. Openings.	3. Provide two emergency escape exits to the surface. Doors between the communication equipment room and other spaces will be fire-rated. Provide one hardened blast door for personnel and one for equipment movement as access to the facility from the main tunnel entrance. Openings will be provided in the roof over the generator operating area for passing exhaust to the exterior to prevent the buildup of fumes in the entrance area.	
4. Ventilation system and humidity control.	4. Install filters to remove dust from the incoming air. Ventilation and humidity requirements will conform to existing criteria for operational spaces. Provide a CBR filter in the ventilation air system for use during the button-up period. Provide openings covered with fire dampers for air circulation between the major areas.	
5. Illumination.	5. Provide standard ADP and office area lighting levels (50 lux).	
6. Power.	6. Provide 177-kW supply for all lighting and communications equipment operation. Provide 110-V a.c. electrical outlets on 10-ft centers throughout the facility for equipment. Provide temporary backup power by a battery-based rotary UPS. Provide permanent backup with portable generators. Energy needed to reject the waste heat, etc. will add approximately 175 kW to the equipment load, raising the needed power generation capacity to approximately 400 kW. Size fuel storage and the cooling system to support at least 7 days of continuous operations without external support.	
7. Heating and cooling.	7. Install equipment to maintain the environment within the standard temperature range for operational spaces. Well-water cooling systems will be used as the primary source. The plenum under the equipment floor will be used for distributing the air supply. Space will be provided above the dropped ceilings for returns. A water source heat pump will be used in conjunction with the well water circulating system to heat the facility.	
8. Survivability protection.	8. Provide HEMP and CBR control. The facility must be capable of being totally buttoned-up for 4 hours without external support. The environment must be maintained to support personnel and equipment in an operational mode during the button-up period.	

requirements	criteria	commentary
9. Fire protection.	9. Install a Halon system below the equipment floor. Install a dry-pipe water sprinkler system with manual override on the ceilings.	
10. Security.	10. Provide space for controlling personnel access to the facility.	
11. Potable water.	11. Allow for approximately 1350 gal/day potable water for operators. Provide water treatment equipment if needed.	
12. Sanitary waste removal.	12. Provide a system for disposing of sanitary waste outside the facility.	
13. Drainage.	13. Provide good drainage to control ground- and surface water at the site.	

guidance

Analysis

The facility design and cost estimates were developed using the same assumptions and processes discussed in Section E, with one exception: the location factor was changed to 1.50 to reflect the cost of construction in Belgium.

Findings and conclusions

The rectangular cast-in-place concrete configuration can be constructed for $1810K, or $215/sq ft. The fibrous concrete multidome configuration can be constructed for $1786K, or $207/sq ft.

The dome configuration should have the shortest construction time, considering the use of inflated forms, spray-applied polyurethane foam form material, and fibrous shotcrete.

The dome-based facility could be constructed in a variety of general configurations. However, the general rectangular shape appears to be the best, considering both room layout and earthwork requirements.

The facility's total cost may be reduced by reconsidering floor space requirements in the nonequipment areas. The spaces indicated are based on those provided in a low-cost unhardened facility. In the dome-based facility, the space may be used more efficiently by reconsidering the passageway in the toilet area and the waiting rooms as well as possible use of storage platforms. Overhead storage space could be constructed to take advantage of the 14-ft ceiling height.

guidance

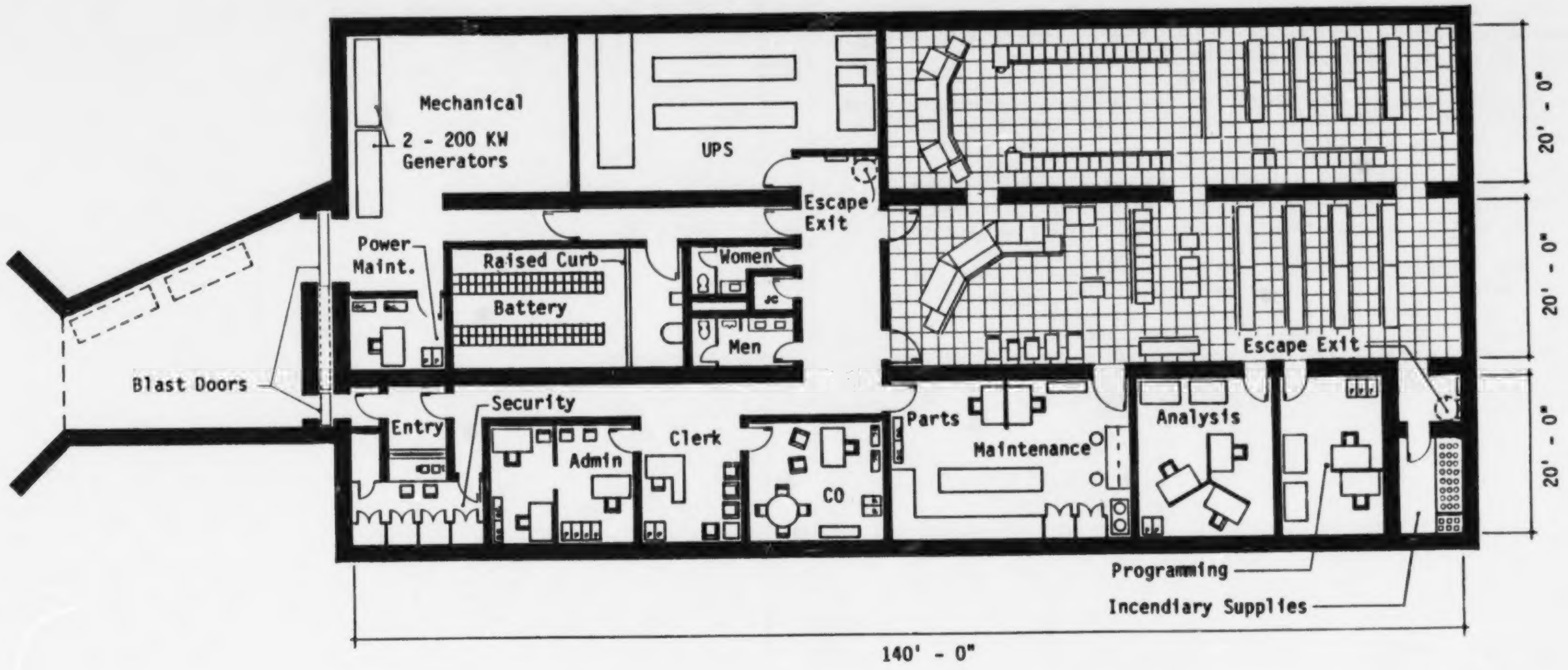
Mechanical
2 - 200 KW Generators
UPS
Escape Exit
Power Maint.
Raised Curb
Battery
Women
JC
Men
Blast Doors
Security
Entry
Admin
Clerk
CO
Parts
Maintenance
Analysis
Escape Exit
Programming
Incendiary Supplies
20' - 0"
20' - 0"
20' - 0"
140' - 0"

FIGURE F-1. AUTODIN SWITCH FACILITY PLAN--RECTANGULAR CONFIGURATION.

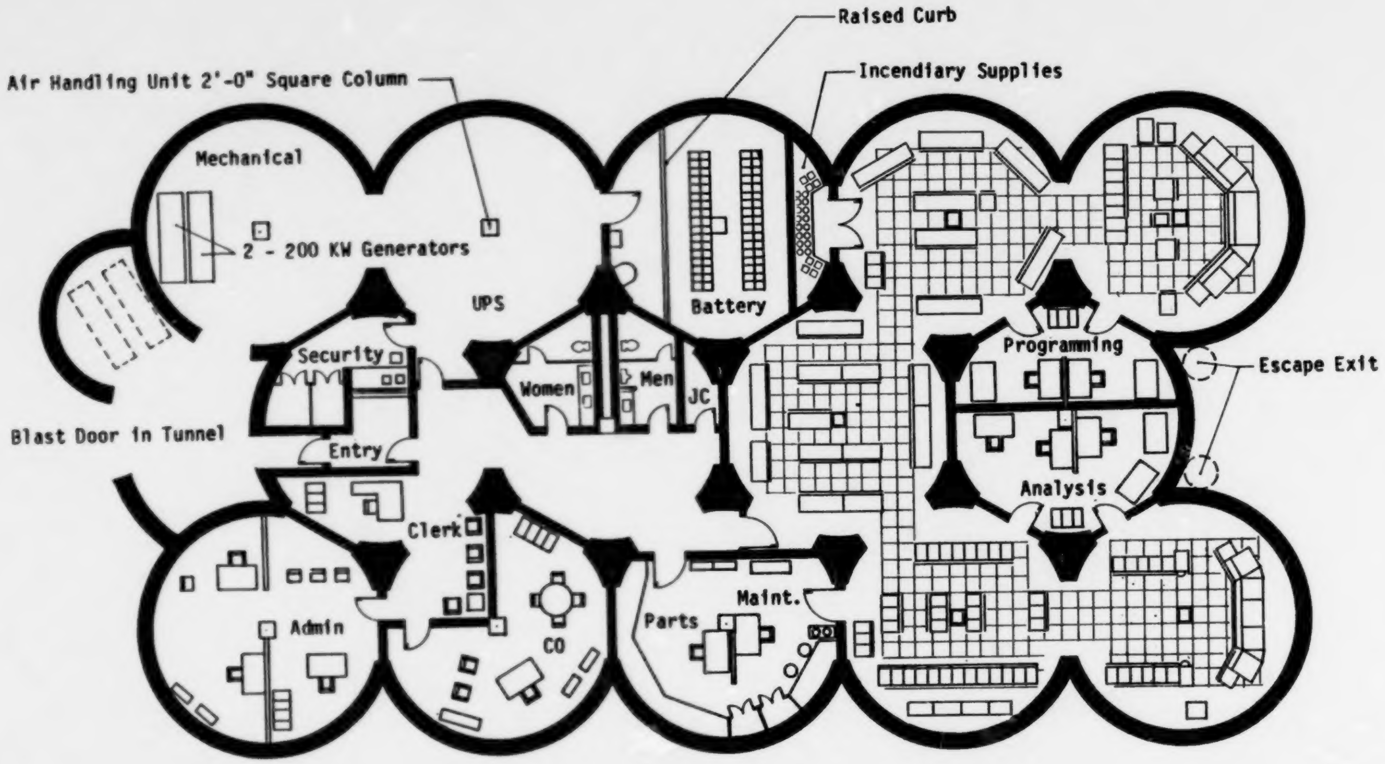
Raised Curb
Incendiary Supplies
Air Handling Unit 2'-0" Square Column
Mechanical
2 - 200 KW Generators
UPS
Battery
Security
Women
Men
JC
Programming
Escape Exit
Blast Door in Tunnel
Entry
Analysis
Clerk
Admin
CO
Parts
Maint.

FIGURE F-2. AUTODIN SWITCH FACILITY PLAN--DOME CONFIGURATION.

METRIC CONVERSIONS

1 ft = .308 m

1 in. = 2.54 cm

1 sq ft = .092 m^2

1 cu ft = .028 m^3

1 cu ft/min = .467 mm^3/sec

1 gal = 3.785 L

1 Lux = 1 lumen/m^2

1 hp = .745 kW

1 lb = .453 kg

1 Ton = 906 kg

1 psi = 6.89 Pa

APPENDIX

COST ESTIMATES

APPENDIX A COST ESTIMATES

Baseline - Conventional Construction

Item #	Description	Est. Quan.	Unit	Bare Costs Mat.	Bare Costs Inst.	Bare Costs Total		Total incl. O&P
1	DCS TRANSPORTABLE UNIT Low Rigid Frame Bldg.				All Costs:	Per S.F.		
	Fdn. 4' depth, 12" x 16" footer			.82	.82	1.65	1.82	2.00
	6" conc. slab, wire mesh reinf.			.82	.82	1.65	1.82	2.00
	Pre-engineered Bldg. Steel frame, gal. steel wall Panels, gal. steel roof			4.12	1.65	5.78	6.36	7.00
	Insulation			.50	.32	.82	.9	1.00
					Total Cost/S.F. =	12.00		
					Total Cost =	$29,670		
	DCS RECONSTITUTIONAL PACKAGE				All Costs:	Per S.F.		
	Fdn. 4' depth, 12" x 16" footer			.82	.82	1.65	1.82	2.00
	6" conc. slab, wire mesh reinf.			.82	.82	1.65	1.82	2.00
	Pre-engineered Bldg. Steel frame, gal. steel wall Panels & Roof Panels			4.71	1.88	6.60	7.27	8.00
	Insulation			.5	.32	.82	.9	1.00
					Total Cost/S.F. =	13.00		
					Total Cost =	$11,440		

Baseline - Reconstitutional Package Storage - Igloo - Condition A

Item #	Description	Est. Quan.	Unit	Bare Costs			Total incl. O&P
				Mat.	Inst.	Total	
1	CONCRETE:						
	Arch	65	C.Y.	6110	9100	15,210	19,825
	Beams	2.5	C.Y.	345	550	895	1175
	Slab	1000	S.F.	940	720	1660	1980
	Footings	35	C.Y.	2625	1330	3955	4725
	Fdn. Walls (Front & Back)	11.5	C.Y.	966	1380	2346	3048
	Walls (Front & Back)	40	C.Y.	3360	4800	8160	10,600
	Fdn. Walls (Sides)	21	C.Y.	1617	1995	3612	4620
	Vent Shaft	21	C.Y.	2079	3570	5649	7455
						Subtotal	53,428
2	REBARS:						
	Footings	3.75	Tons	1856	1144	300	3750
	Fdn. Walls	9.5	Tons	4703	2043	6745	8265
	Walls and Arch	16.7	Tons	8266	3591	11,857	14,529
	Floor Slab	1.0	Ton	485	280	765	960
						Subtotal	27,504
3	FORMS:						
	Footings	1461	SFCA	424	1753	2177	2951
	Keyway	200	L.F.	14	56	70	96
	Beams	300	SFCA	126	447	573	774
	Floor Slab	150	L.F.	23	146	168	231
	Fnd. Wall	546	SFCA	251	972	1223	1660
	Front & Rear Wall	2396	SFCA	1102	4265	5367	7284
	Arch & Side Walls	5760	SFCA	3514	15,437	18,950	25,862
						Subtotal	38,858

Reconstitutional Package Storage--Igloo, cont'd

4	FINISHING:						
	Floor:						
	Screed	1000	SF	-	160	160	220
	Trowel	1000	SF	-	310	310	420
	Walls	3000	SF	210	1440	1650	2250
						Subtotal	2890
5	SECURITY DOORS	UNIT PRICE - 124,000					
6	MOISTURE PROTECTION:						
	Slab Vapor Barrier	10	Sq	54	40	94	116.5
	Membrane Waterproofing* (Arch)	2000	S.F.	1660	1280	2940	3700
	Membrane Waterproofing (Front & Walls)	2400	S.F.	1992	1766	3758	4670
	Caulking	50	L.F.	33	42	75	96
						Subtotal	8583
	*3-ply fabric						
7	SITE WORK:						
	Excavation (Bldg)	148	CY	188	175	363	459
	Footings	180	CY	193	243	436	560
	Excavation (Road)	65	CY	70	17	87	102
	Compacted Backfill	948	CY	958	304	1261	1498
	Road - 3" deep stone	89	SY	75	26	101	116
	Erosion Control	517	SY	285	78	362	424
	Fine Grading & Seeding	517	SY	93	465	558	739
						Subtotal	3878
						TOTAL	$259,161

Baseline - Reconstitutional Package Storage - Igloo - Condition B

Item #	Description	Est. Quan.	Unit	Bare Costs			Total incl. O&P
				Mat.	Inst.	Total	
1	CONCRETE: Same as condition A except; subtract portal wall portions,					A Subtotal	53,428
	Footings	2	C.Y.	150	76	226	- 270
	Foundation Wall	2	C.Y.	168	240	408	- 530
						Subtotal	52,628
2	REBARS: Same as condition A except:					A Subtotal	27,504
	Footing	.1	Tons	49.5	30.5	80	- 100
	Fdn. Walls & Walls	.34	Tons	169	73	242	- 280
						Subtotal	27,108
3	FORMS: Same as condition A except:					A Subtotal	38,858
	Footings	150	SFCA	44	180	224	- 303
	Fdn. & Walls	92	SFCA	43	164	207	- 208
						Subtotal	38,275
4	FINISHING: Same as condition A						2,890
5	SECURITY DOORS						124,000
6	MOISTURE PROTECTION: Same as condition A except					A Subtotal	8583
	Membrane Waterproofing	50	S.F.	42	32	74	- 93
						Subtotal	8,490
7	SITE WORK:						
	Excavation (Bldg)	553	CY	702	653	1355	1714
	Excavation (Road)	554	Cy	593	144	737	865
	Compacted Backfill	454	CY	459	145	604	717
	Roadway 3" deep stone	211	SY	180	61	241	275
	Erosion Control	476	SY	262	72	333	390
	Fine Grading & Seeding	476	SY	86	428	514	681
						Subtotal	4,642
						TOTAL	$258,033

Baseline - Reconstitutional Package Storage - Igloo - Condition C

Item #	Description	Est. Quan.	Unit	Bare Costs			Total incl. O&P
				Mat.	Inst.	Total	
1	CONCRETE:						
	Same as condition A except:					A Subtotal	53,428
	Footings	14.8	C.Y.	1111	563	1674	- 2000
	Fdn. Wall	4.7	C.Y.	398	568	966	- 1255
	Portal Wall	19	C.Y.	1596	2280	3876	- 5035
						Subtotal	45,138
2	REBARS:						
	Same as condition A except					A Subtotal	27,504
	Footing/Fdn.	.77	Tons	381	234	616	- 770
	Portal Wall	.71	Tons	352	153	504	- 3113
						Subtotal	26,116
3	FORMS:						
	Same as condition A except:					A subtotal	38,858
	Footing (Portal)	530	SFCA	154	636	790	- 1071
	Fdn. Wall (Portal)	250	SFCA	115	445	560	- 760
	Portal Wall	1024	SFCA	471	1822	2294	- 3113
						Subtotal	33,914
4	FINISHING Same as condition A						2,890
5	SECURITY DOOR						124,000
6	MOISTURE PROTECTION:						
	Same as condition A except:					A subtotal	8583
	Membrane Waterproofing	512	S.F.	425	328	753	- 948
						Subtotal	7,635
7	SITE WORK:						
	Excavation (Bldg)	1477	C.Y.	1876	1743	3619	4579
	Excavation (Road)	3111	C.Y.	3951	3671	7622	9644
	Compacted Backfill	855	C.Y.	864	274	1137	1351
	Roadway - 3" deep stone	444	SY	378	129	507	578
	Erosion Control	407	SY	224	61	285	334
	Fine Grading & Seeding	407	SY	74	366	440	582
						Subtotal	17,068
						TOTAL	$256,761

Baseline - Transportable Unit Storage - Igloo - Condition A

Item #	Description	Est. Quan.	Unit	Bare Costs			Total incl. O&P
				Mat.	Inst.	Total	
1	CONCRETE:						
	Arch	194	C.Y.	18,236	27,160	45,496	59,170
	Beams	7	C.Y.	966	1540	2506	3290
	Slab	3000	S.F.	2820	2160	4980	5940
	Footings	103	C.Y.	7725	3914	11,639	13,905
	Fdn. Walls/Front & Back	11.5	C.Y.	966	1380	2346	3048
	Walls (Front & Back)	40	C.Y.	3360	4800	8160	10,600
	Fdn. Walls (Sides)	63	C.Y.	4850	5985	10,835	13,860
	Vent Shaft	21	C.Y.	2079	3570	5649	7455
						Subtotal	117,268
2	REBARS:						
	Footings	4.13	Tons	2044	1260	3304	4130
	Fdn. Walls	10.75	Tons	5321	2311	7633	9353
	Walls & Arch	50	Tons	24,750	10,750	35,500	43,500
	Floor Slab	3.0	Tons	1476	855	2329	2923
						TOTAL	59,906
3	FORMS:						
	Footings	2940	SFCA	853	3528	4381	5939
	Keyway	360	LF	36	108	144	191
	Beams	825	SFCA	347	1230	1576	2129
	Floor Slab	360	LF	54	350	403	555
	Fdn. Walls	988	SFCA	454	1759	2213	3004
	Front & Rear Walls	2396	SFCA	1102	4265	5367	7284
	Arch & Side Walls	11,520	SFCA	7027	30,847	37,900	51,725
						Subtotal	70,827

Transportable Unit Storage--Igloo, cont'd

4	FINISHING:						
	Floor:						
	Screed	3000	SF	-	480	480	660
	Troweling	3000	SF	-	930	930	1260
	Walls	5520	SF	387	2650	3036	4140
						Subtotal	6,060
5	SECURITY DOORS 1-15' x 18' x 14"					Unit Price	124,000
6	MOISTURE PROTECTION:						
	Slab Vapor Barrier (.010 thick) (Arch)	30	Sq	162	120	282	350
	Membrane Waterproofing (Front & Rear Walls)	2400	S.F.	1992	1766	3758	4670
	Caulking (Reglets)	s50	L.F.	33	42	75	96
						Subtotal	16,792
7	SITE WORK:						
	Excavation (Bldg) Backhoe	1443	C.Y.	563	523	1086	1374
	Footings - Backhoe	180	C.Y.	193	243	436	560
	Excavation (Roadway) Dozer	65	C.Y.	70	17	87	102
	Compacted Backfill	2845	C.Y.	2874	910	3784	4495
	Roadway 3" deep stone	89	S.Y.	75	26	101	116
	Erosion Control	1550	S.Y.	853	233	1085	1271
	Fine Grading & Seeding	1550	S.Y.	279	1395	1674	2217
						Subtotal	10,135
						TOTAL	$404,988

Baseline - Transportable Unit Storage - Igloo - Condition B

Item #	Description	Est. Quan.	Unit	Bare Costs			Total incl. O&P
				Mat.	Inst.	Total	
1	**CONCRETE:**						
	Same as condition A except subtract volume accordingly to reduced portal wall size.					A subtotal	117,268
	Footings	2	C.Y.	150	76	226	- 270
	Fdn. Wall	2	C.Y.	168	240	408	- 530
						Subtotal	116,468
2	**REBARS:**					A subtotal	59,906
	Footing	.1	Tons	49.5	30.5	80	- 100
	Fdn. Walls & Walls	.34	Tons	169	73	242	- 280
						Subtotal	59,510
3	**FORMS:**						70,827
	Same as condition A except:						
	Footings	150	SFCA	44	180	224	- 303
	Fdn. Wall	92	SFCA	43	164	207	- 280
						Subtotal	70,244
4	**FINISHING** Same as condition A						6,060
5	**SECURITY DOORS** Same as condition A						124,000
6	**MOISTURE PROTECTION:**						
	Same as condition A except						16,792
	Membrane Waterproofing	50	SF	42	32	74	- 93
						Subtotal	16,700
7	**SITE WORK:**						
	Excavation (Bldg) (Backhoe)	1660	C.Y.	2108	1959	4067	5146
	Excavation (Roadway) (Dozer)	554	C.Y.	593	144	737	865
	Compacted Backfill	1363	C.Y.	1377	436	1813	2154
	Roadway 3" deep stone	211	S.Y.	180	61	241	275
	Erosion Control	1427	S.Y.	785	214	999	1170
	Fine Grading & Seeding	1427	S.Y.	257	1285	1541	2041
						Subtotal	11,651
						TOTAL	$404,633

Baseline - Transportable Unit Storage - Igloo - Condition C

Item #	Description	Est. Quan.	Unit	Bare Costs			Total incl. O&P
				Mat.	Inst.	Total	
1	CONCRETE:						
	Same as condition A except subtract:					A subtotal	117,268
	Footings (Portal Wall)	14.8	C.Y.	1111	563	1674	- 2000
	Fdn. Wall (Portal Wall)	4.7	C.Y.	398	568	966	- 1255
	Portal Wall	19	C.Y.	1596	2280	3876	- 5035
						Subtotal	108,978
2	REBARS:						
	Same as condition A except:					A subtotal	59,906
	Footing/Fdn.	.77	Tons	381	234	616	- 770
	Portal Wall	.71	Tons	352	153	504	- 618
						Subtotal	58,518
3	FORMS:						
	Same as condition A except:					A subtotal	70,827
	Footing (Portal)	530	SFCA	154	636	790	- 1071
	Fdn. Wall (Portal)	250	SFCA	115	445	560	- 760
	Portal Wall	1024	SFCA	471	1822	2294	- 3313
						Subtotal	65,883
4	FINISHING Same as condition A						6,060
5	SECURITY DOORS: Same as condition A						124,000
6	MOISTURE PROTECTION:						
	Same as condition A except:					A subtotal	16,792
	Membrane Waterproofing	512	S.F.	425	328	753	- 948
						Subtotal	15,844
7	SITE WORK:						
	Excavation (Bldg)	4430	C.Y.	4429	6168	10,854	13,733
	Excavation (Road)	3111	C.Y.	3951	3671	7622	9644
	Compacted Backfill	2565	C.Y.	2591	821	3412	4053
	Roadway - 3" deep stone	444	S.Y.	378	129	507	578
	Erosion Control	1222	S.Y.	672	184	856	1002
	Fine Grading & Seeding	1222	S.Y.	220	1100	1320	1748
						Subtotal	30,758
						TOTAL	410,041

TRANSPORTABLE UNIT SHELTER

RECTANGULAR CONFIGURATION

DCS Transportable Unit Shelter Cost Estimate
Cast-in-Place Concrete Rectangular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Cast-in-place concrete	CY	440	200.	88.0
Reinforcing steel	T	94	1000.	94.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		13,400.	13.4
Electrical	LS		75,600.	75.6
Drainage	LS		5,600.	5.6
Waterproofing	SY	1090	5.50	6.0
Excavation	CY	9980	3.00	29.9
Backfill	CY	5710	6.00	34.3
Rock rubble	CY	1700	4.00	6.8
Disposal	CY	4280	2.50	10.7
Seeding	LS		960.	1.0
Unadjusted Facility Costs				$492.8k

Location adjustment factor (Washington, DC) 1.00
Contingency factor 1.05
Supervision and administration factor 1.05
Construction data factor (Jan 84) 1.00

Adjusted Facility Cost $492.8 x 1.00 x 1.05 x 1.05 x 1.00 = $543.3k

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*Range between bomb and structure equals 100 ft.

DCS Transportable Unit Shelter Cost Estimate
Precast Segmental Unit Rectangular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Precast concrete	CY	470	175.	82.3
Reinforcing steel	T	102	1,000.	102.0
Post-tensioning system	LS		25,000.	25.0
Blast door	LS		127,500.	127.5
Mechanical	LS		13,400.	13.4
Electrical	LS		75,600.	75.6
Drainage	LS		5,600.	5.6
Waterproofing	SY	1120	5.50	6.2
Excavation	CY	10,060	3.00	30.2
Backfill	CY	5,740	6.00	34.4
Rock rubble	CY	1,720	4.00	6.9
Disposal	CY	4,325	2.50	10.8
Seeding	LS		1,000.	1.0
Unadjusted Facility Cost				$520.9k

Location adjustment factor (Washington, DC) 1.00
Contingency factor 1.05
Supervision and administration factor 1.05
Construction data factor (Jan 84) 1.05

Adjusted Facility Cost $520.9k x 1.00 x 1.05 x 1.05 x 1.00 = $574.3k

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*Range between bomb and structure equals 100 ft.

DCS Transportable Unit Shelter Cost Estimate
Precast Elements Rectangular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Precast concrete	CY	535	175.	93.6
Reinforcing steel	T	118	1,000.	118.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		13,400.	13.4
Electrical	LS		75,600.	75.6
Drainage	LS		5,600.	5.6
Waterproofing	SY	1140	5.50	6.3
Excavation	CY	10,265	3.00	30.8
Backfill	CY	5,815	6.00	34.9
Rock rubble	CY	1,765	4.00	7.1
Disposal	CY	4,455	2.50	11.1
Seeding	LS		1,000.	1.0
Unadjusted Facility Costs				$524.9k

Location adjustment factor (Washington, DC)	1.00
Contingency factor	1.05
Supervision and administration factor	1.05
Construction data factor (Jan 84)	1.00

Adjusted Facility Cost $524.9k x 1.00 x 1.05 x 1.05 x 1.00 = $578.7

---

*Range between bomb and structure equals 100 ft.

DCS Transportable Unit Shelter Cost Estimate
Precast Tilt-up Rectangular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Cast-in-place concrete	CY	618	150.	92.7
Reinforcing steel	T	140	1,000.	140.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		13,400.	13.4
Electrical	LS		75,600.	75.6
Drainage	LS		5,700.	5.7
Waterproofing	SY	1,170	5.50	6.4
Excavation	CY	10,550	3.00	31.6
Backfill	CY	5,920	6.00	35.5
Rock rubble	CY	1,820	4.00	7.3
Disposal	CY	4,630	2.50	11.6
Seeding	LS		1,000.	1.0
Unadjusted Facility Cost				$548.3k

Location adjustment factor (Washington, DC)	1.00
Contingency factor	1.05
Supervision and administration factor	1.05
Construction data factor (Jan 84)	1.00

Adjusted Facility Cost $548.3k x 1.00 x 1.05 x 1.05 x 1.00 = $604.5k

---

*Range between bomb and structure equals 100 ft.

DCS Transportable Unit Shelter Cost Estimate
Double Panel Wall Rectangular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Cast-in-place concrete	CY	600	200.	120.0
Reinforcing steel	T	135	1,000.	135.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		13,400.	13.4
Electrical	LS		75,600.	75.6
Drainage	LS		5,900.	5.9
Waterproofing	SY	1,350	5.50	7.4
Excavation	CY	11,590	3.00	34.8
Backfill	CY	6,250	6.00	37.5
Rock rubble	CY	2,045	4.00	8.2
Disposal	CY	5,330	2.50	13.3
Seeding	LS		1,100.	1.1
Unadjusted Facility Cost				$579.7k

Location adjustment factor (Washington, DC) 1.00
Contingency factor 1.05
Supervision and administration factor 1.05
Construction data factor (Jan 84) 1.00

Adjusted Facility Cost $579.7k x 1.00 x 1.05 x 1.05 x 1.00 = $639.1k

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*Range between bomb and structure equals 100 ft.

DCS Transportable Unit Shelter Cost Estimate
Shotcrete Rectangular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Shotcrete	CY	500	350.	175.0
Reinforcing Steel	T	110	1,000.	110.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		13,400.	13.4
Electrical	LS		75,600.	75.6
Drainage	LS		5,600.	5.6
Waterproofing	SY	1125	5.50	6.2
Excavation	CY	10,165	3.00	30.5
Backfill	CY	5,775	6.00	34.6
Rock rubble	CY	1,740	4.00	7.0
Disposal	CY	4,390	2.50	11.0
Seeding	LS		1,000.	1.0
Unadjusted Facility Cost				$597.4k

Location adjustment factor (Washington, DC) 1.00
Contingency factor 1.05
Supervision and administration factor 1.05
Construction data factor (Jan 84) 1.00

Adjusted Facility Cost $597.4k x 1.00 x 1.05 x 1.05 x 1.00 = $658.6k

---

*Range between bomb and structure equals 100 ft.

TRANSPORTABLE UNIT SHELTER

CIRCULAR CONFIGURATION

DCS Transportable Unit Shelter Cost Estimate
Cast-in Place Concrete Circular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Cast-in-place concrete	CY	415	300.	124.5
Reinforcing steel	T	87	1,200.	104.4
Blast doors	LS		127,500.	127.5
Mechanical	LS		13,400.	13.4
Electrical	LS		75,600.	75.6
Drainage	LS		5,600.	5.6
Waterproofing	SY	870	5.50	4.8
Excavation	CY	10,440	3.00	31.3
Backfill	CY	5,120	6.00	30.7
Rock rubble	CY	1,800	4.00	7.2
Disposal	CY	3,320	2.50	8.3
Seeding	LS		1,000.	1.0
Unadjusted Facility Cost				$539.3k

Location adjustment factor (Washington, DC) 1.00
Contingency factor 1.05
Supervision and administration factor 1.05
Construction data factor (Jan 84) 1.00

Adjusted Facility Cost $521.9 x 1.00 x 1.05 x 1.05 x 1.00 = $594.6k

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*Range between bomb and structure equals 100 ft.

DCS Transportable Unit Shelter Cost Estimate
Precast Segmental Unit Circular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Precast concrete	CY	430	250.	107.5
Reinforcing steel	T	90	1,200.	108.0
Post-tensioning system	LS		25,000.	25.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		13,400.	13.4
Electrical	LS		75.6	75.6
Drainage	LS		5,700.	5.7
Waterproofing	SY	875	5.50	4.8
Excavation	CY	10,500	3.00	31.5
Backfill	CY	5,150	6.00	30.9
Rock rubble	CY	1,820	4.00	7.3
Disposal	CY	5,355	2.50	13.4
Seeding	LS		1,000.	1.0
Unadjusted Facility Cost				$551.6k

Location adjustment factor (Washington, DC) 1.00
Contingency factor 1.05
Supervision and administration factor 1.05
Construction data factor (Jan 84) 1.00

Adjusted Facility Cost $551.6k x 1.00 x 1.05 x 1.05 x 1.00 = $608.1k

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*Range between bomb and structure equals 100 ft.

DCS Transportable Unit Shelter Cost Estimate
Corrugated Steel/Fibrous Concrete Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Fibrous concrete	CY	96	350.	33.6
Cast-in-place concrete	CY	245	200.	49.0
Reinforcing fibers	LB	25,400	0.50	12.7
Reinforcing steel	T	41	1,000.	41.0
Corrugated steel plate	LS		94,000.	9.4
Foam	SF	8,070	3.00	24.2
Blast doors	LS		127,500.	127.5
Mechanical	LS		13,400.	13.4
Electrical	LS		75,600.	75.6
Drainage	LS		5,600.	5.6
Waterproofing	SY	890	5.50	4.9
Excavation	CY	10,570	3.00	31.7
Backfill	CY	5,175	6.00	31.1
Rock rubble	CY	1,330	4.00	5.3
Disposal	CY	5,400	2.50	13.5
Seeding	LS		1,000	1.0
Unadjusted Facility Costs				$566.1k

Location adjustment factor (Washington, DC) 1.00
Contingency factor 1.05
Supervision and administration factor 1.05
Construction data factor (Jan 84) 1.00

Adjusted Facility Cost $566.1k x 1.00 x 1.05 x 1.05 x 1.00 = $624.1k

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*Range between bomb and structure equals 100 ft.

DCS Transportable Unit Shelter Cost Estimate
Shotcrete Circular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Shotcrete	CY	452	400.	180.8
Reinforcing steel	T	96	1,200.	115.2
Blast doors	LS		127,500.	127.5
Mechanical	LS		13,400.	13.4
Electrical	LS		75,600.	75.6
Drainage	LS		5,600.	5.6
Waterproofing	SY	885	5.50	4.9
Excavation	CY	10,585	3.00	31.8
Backfill	CY	5,180	6.00	31.1
Rock rubble	CY	1,835	4.00	7.3
Disposal	CY	5,405	2.50	13.5
Seeding	LS		1,000	1.0
Unadjusted Facility Cost				$607.7k

Location adjustment factor (Washington, DC) 1.00
Contingency factor 1.05
Supervision and administration factor 1.05
Construction data factor (Jan 84) 1.00

Adjusted Facility Cost $607.7k x 1.00 x 1.05 x 1.05 x 1.00 = $669.9k

---

*Range between bomb and structure equals 100 ft.

RECONSTITUTIONAL PACKAGE SHELTER

RECTANGULAR CONFIGURATION

DCS Reconstitutional Package Shelter Cost Estimate
Cast-in-Place Concrete Rectangular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Cast-in-place concrete	CY	290	200.	58.0
Reinforcing steel	T	55	1,000.	55.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		12,200.	12.2
Electrical	LS		54,400.	54.4
Drainage	LS		3,700.	3.7
Waterproofing	SY	495	5.50	2.7
Excavation	CY	6395	3.00	19.2
Backfill	CY	3785	6.00	22.7
Rock rubble	CY	900	4.00	3.6
Disposal	CY	2,610	2.50	6.5
Seeding	LS		500	0.5
Unadjusted Facility Cost				$366.0k

Location adjustment factor (Washington, DC) 1.00
Contingency factor 1.05
Supervision and administration factor 1.05
Construction data factor (Jan 84) 1.00

Adjusted Facility Cost $366.0k x 1.00 x 1.05 x 1.05 x 1.00 = $403.5k

---

*Range between bomb and structure equals 100 ft.

DCS Reconstitutional Package Shelter Cost Estimate
Precast Tilt-up Rectangular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Precast concrete	CY	375	150.	56.3
Reinforcing steel	T	75	1,000.	75.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		12,200.	12.2
Electrical	LS		54,400.	54.4
Drainage	LS		3,700.	3.7
Waterproofing	SY	530	5.50	2.9
Excavation	CY	6,765	3.00	20.3
Backfill	CY	3,945	6.00	23.7
Rock rubble	CY	980	4.00	3.9
Disposal	CY	2,825	2.50	7.1
Seeding	LS		600.	0.6
Unadjusted Facility Cost				$387.6k

Location adjustment factor (Washington, DC) 1.00
Contingency factor 1.05
Supervision and administration factor 1.05
Construction data factor (Jan 84) 1.00

Adjusted Facility Cost $387.6k x 1.00 x 1.05 x 1.05 x 1.00 = $427.3k

---

*Range between bomb and structure equals 100 ft.

DCS Reconstitutional Package Shelter Cost Estimate
Precast Tilt-up Rectangular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Precast concrete	CY	375	150.	56.3
Reinforcing steel	T	75	1,000.	75.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		12,200.	12.2
Electrical	LS		54,400.	54.4
Drainage	LS		3,700.	3.7
Waterproofing	SY	530	5.50	2.9
Excavation	CY	6,765	3.00	20.3
Backfill	CY	3,945	6.00	23.7
Rock rubble	CY	980	4.00	3.9
Disposal	CY	2,825	2.50	7.1
Seeding	LS		600.	0.6

Unadjusted Facility Cost $387.6k

Location adjustment factor (Washington, DC)	1.00
Contingency factor	1.05
Supervision and administration factor	1.05
Construction data factor (Jan 84)	1.00

Adjusted Facility Cost $387.6k x 1.00 x 1.05 x 1.05 x 1.00 = $427.3k

---

*Range between bomb and structure equals 100 ft.

DCS Reconstitutional Package Shelter Cost Estimate
Precast Segmental Rectangular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Precast concrete	CY	305	175.	53.4
Reinforcing steel	T	58	1,000.	58.0
Post-tensioning system	LS		17,000.	17.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		12,200.	12.2
Electrical	LS		54,400.	54.4
Drainage	LS		3,700.	3.7
Waterproofing	SY	500	5.50	2.8
Excavation	CY	6,450	3.00	19.3
Backfill	CY	3,810	6.00	22.9
Rock rubble	CY	910	4.00	3.6
Disposal	CY	2,640	2.50	6.6
Seeding	LS		510	0.5

Unadjusted Facility Costs $381.9k

Location adjustment factor (Washington, DC)	1.00
Contingency factor	1.05
Supervision and administration factor	1.05
Construction data factor (Jan 84)	1.00

Adjusted Facility Cost $381.9k x 1.00 x 1.05 x 1.05 x 1.00 = $421.0k

---

*Range between bomb and structure equals 100 ft.

DCS Reconstitutional Package Shelter Cost Estimate
Shotcrete Rectangular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Shotcrete	CY	320	350.	112.0
Reinforcing steel	T	62	1,000.	62.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		12,200.	12.2
Electrical	LS		54,400.	54.4
Drainage	LS		3,700.	3.7
Waterproofing	SY	510	5.50	2.8
Excavation	CY	6,515	3.00	19.5
Backfill	CY	3,840	6.00	23.0
Rock rubble	CY	925	4.00	3.7
Disposal	CY	2,680	2.50	6.7
Seeding	LS		520	0.5
Unadjusted Facility Cost				$428.0k

Location adjustment factor (Washington, DC)	1.00
Contingency factor	1.05
Supervision and administration factor	1.05
Construction data factor (Jan 84)	1.00

Adjusted Facility Cost $428.0k x 1.00 x 1.05 x 1.05 x 1.00 = $471.9k

---

*Range between bomb and structure equals 100 ft.

DCS Reconstitutional Package Shelter Cost Estimate
Precast Elements Rectangular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Precast concrete	CY	332	175.	58.1
Reinforcing steel	T	65	1,000.	65.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		12,200.	12.2
Electrical	LS		54,400.	54.4
Drainage	LS		3,700.	3.7
Waterproofing	SY	515	5.50	2.8
Excavation	CY	6,580	3.00	19.7
Backfill	CY	3,865	6.00	23.2
Rock rubble	CY	940	4.00	3.8
Disposal	CY	2,720	2.50	6.8
Seeding	LS		500.	0.5
Unadjusted Facility Cost				$377.7k

Location adjustment factor (Washington, DC)	1.00
Contingency factor	1.05
Supervision and administration factor	1.05
Construction data factor (Jan 84)	1.00

Adjusted Facility Cost $377.7k x 1.00 x 1.05 x 1.05 x 1.00 = $416.4k

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*Range between bomb and structure equals 100 ft.

RECONSTITUTIONAL PACKAGE SHELTER

CIRCULAR CONFIGURATION

DCS Reconstitutional Package Shelter Cost Estimate
Cast-in-Place Concrete Circular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Cast-in-place concrete	CY	280	300.	84.0
Reinforcing steel	LS	50	1,200.	60.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		12,200.	12.2
Electrical	LS		54,400.	54.4
Drainage	LS		3,700.	3.7
Waterproofing	SY	375	5.50	2.1
Excavation	CY	6,700	3.00	20.1
Backfill	CY	2,950	6.00	17.7
Rock rubble	CY	970	4.00	3.9
Disposal	CY	3,750	2.50	9.4
Seeding	LS		500.	0.5
Unadjusted Facility Cost				$395.5

Location adjustment factor (Washington, DC)	1.00
Contingency factor	1.05
Supervision and administration factor	1.05
Construction data factor (Jan 84)	1.00

Adjusted Facility Cost $395.5k x 1.00 x 1.05 x 1.05 x 1.00 = $436.0k

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*Range between bomb and structure equals 100 ft.

DCS Reconstitutional Package Shelter Cost Estimate
Precast Segmental Unit Circular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Precast concrete	CY	290	250.	72.5
Reinforcing steel	T	53	1,200.	63.6
Post-tensioning system	LS		17,000.	17.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		12,200.	12.2
Electrical	LS		54,400.	54.4
Drainage	LS		3,700.	3.7
Waterproofing	SY	380	5.50	2.1
Excavation	CY	6,735	3.00	20.2
Backfill	CY	2,965	6.00	17.8
Rock rubble	CY	975	4.00	3.9
Disposal	CY	3,775	2.50	9.4
Seeding	LS		500	0.5
Unadjusted Facility Cost				$404.8k

Location adjustment factor (Washington, DC)	1.00
Contingency factor	1.05
Supervision and administration factor	1.05
Construction data factor (Jan 84)	1.00

Adjusted Facility Cost $404.8k x 1.00 x 1.05 x 1.05 x 1.00 = $446.3k

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*Range between bomb and structure equals 100 ft.

DCS Reconstitutional Package Shelter Cost Estimate
Shotcrete Circular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Shotcrete	CY	300	400.	120.0
Reinforcing steel	T	55	1,200.	66.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		12,200.	12.2
Electrical	LS		54,400.	54.4
Drainage	LS		3,700.	3.7
Waterproofing	SY	385	5.50	2.1
Excavation	CY	6,790	3.00	20.4
Backfill	CY	2,990	6.00	17.9
Rock rubble	CY	985	4.00	3.9
Disposal	CY	3,805	2.50	9.6
Seeding	LS		500	0.5
Unadjusted Facility Cost				$438.2k

Location adjustment factor (Washington, DC) 1.00
Contingency factor 1.05
Supervision and administration factor 1.05
Construction data factor (Jan 84) 1.00

Adjusted Facility Cost $438.2k x 1.00 x 1.05 x 1.05 x 1.00 = $483.1k

---

*Range between bomb and structure equals 100 ft.

OPERATIONAL SHELTER

DCS Integrated Operational and Transportable Unit Shelter Cost Estimate
Cast-in-place Concrete Rectangular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Cast-in-place concrete	CY	785	200.	157.0
Reinforcing steel	T	185	1,000.	185.0
Blast doors	LS		127,500.	127.5
Mechanical	LS		50,800.	50.8
Electrical	LS		167,600.	167.6
Drainage	LS		8,000.	8.0
Waterproofing	SY	2,000	5.50	11.0
Excavation	CY	13,510	3.00	40.5
Backfill	CY	6,385	6.00	38.3
Rock rubble	CY	2,690	4.00	10.8
Disposal	CY	7,130	2.50	17.8
Seeding	LS		1,500.	1.5
Unadjusted Facility Cost				$815.8k

Location adjustment factor (Washington, DC)	1.00
Contingency factor	1.05
Supervision and administration factor	1.05
Construction data factor (Jan 84)	1.00

Adjusted Facility Cost $815.8k x 1.00 x 1.05 x 1.05 x 1.00 = $899.4k

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*Range between bomb and structure equals 100 ft.

DCS Operational Shelter Cost Estimate
Cast-in-place Concrete Rectangular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Cast-in-place concrete	CY	620	200.	124.0
Reinforcing steel	T	145	1,000.	145.0
Blast doors	LS		57,500.	57.5
Mechanical	LS		50,800.	50.8
Electrical	LS		154,200.	154.2
Drainage	LS		4,500.	4.5
Waterproofing	SY	1,490	5.50	8.2
Excavation	CY	10,365	3.00	31.1
Backfill	CY	5,060	6.00	30.4
Rock rubble	CY	1,930	4.00	7.7
Disposal	CY	5,315	2.50	13.3
Seeding	LS		650.	0.7
Unadjusted Facility Cost				$627.4k

Location adjustment factor (Washington, DC)	1.00
Contingency factor	1.05
Supervision and administration factor	1.05
Construction data factor (Jan 84)	1.00

Adjusted Facility Cost $627.4k x 1.00 x 1.05 x 1.05 x 1.00 = $691.7k

---

*Range between bomb and structure equals 100 ft.

DCS Operational Shelter Cost Estimate
Dome Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Fibrous concrete	CY	140	350.	49.0
Cast-in-place concrete	CY	160	200.	32.0
Reinforcing fibers	LB	25,400	0.50	12.7
Reinforcing steel	T	16	1,000.	16.0
Foam	SF	6,160	6.00	37.0
Blast doors	LS		57,500.	57.5
Mechanical	LS		50,800.	50.8
Electrical	LS		154,200.	154.2
Waterproofing	SY	1,140	5.50	6.3
Drainage	LS		5,600.	5.6
Excavation	CY	160	3.00	0.5
Backfill	CY	9,200	6.00	55.2
Rock rubble	CY	2,360	4.00	9.4
Borrow	CY	8,990	2.50	22.5
Seeding	LS		1,200.	1.2
Unadjusted Facility Cost				$509.9k

Location adjustment factor (Washington, DC) 1.00
Contingency factor 1.05
Supervision and administration factor 1.05
Construction data factor (Jan 84) 1.00

Adjusted Facility Cost $509.8k x 1.00 x 1.05 x 1.05 x 1.00 = $562.2k

---

*Range between bomb and structure equals 100 ft.

DCS Operational Shelter Cost Estimate
Concrete/Prefabricated Box Form Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Cast-in-place concrete	CY	196	200.	39.2
Reinforcing steel	T	26	1,000.	26.0
Blast doors	LS		57,500.	57.5
Milvans	EA	19	12,500.	237.5
Mechanical	LS		50,800.	50.8
Electrical	LS		154,200.	154.2
Waterproofing	SY	1,010	5.50	5.5
Drainage	LS		5,600.	5.6
Excavation	CY	5,740	3.00	17.2
Backfill	CY	2,170	6.00	13.0
Rock rubble	CY	2,530	4.00	10.1
Disposal	CY	1,040	2.50	2.6
Seeding	LS		1,500.	1.5
Unadjusted Facility Cost				$620.7k

Location adjustment factor (Washington, DC) 1.00
Contingency factor 1.05
Supervision and administration factor 1.05
Construction data factor (Jan 84) 1.00

Adjusted Facility Cost $620.7k x 1.00 x 1.05 x 1.05 x 1.00 = $684.3k

---

*Range between bomb and structure equals 100 ft.

CASE STUDY

In order to present a realistic application of the results from this investigation, construction cost estimates have been developed for hypothetical operational shelters to be located at Chievres AB, Belgium, near Supreme Headquarters Allied Powers Europe. The shelters were required to withstand overpressures due to blasts from near misses by bombs exploding at ranges of 75 ft or more. Of the several types of semihardened operational shelters, two were considered: the cast-in-place concrete rectangular construction and the fibrous concrete dome construction. The floor plans for the two shelters are presented in Figure G-1 and G-2 respectively. The given floor space areas for the rectangular and dome configurations are 8400 sq ft and 8620 sq ft, respectively. Both structures were covered with 8 ft of soil and rock as shown in Figure D-33. The rectangular shelter was buried while the dome shelter was mounded.

For the purpose of cost estimation, several assumptions were made:

1. The location adjustment factor for Belgium is 1.50
2. The contingency factor is 1.05
3. The supervision and administration factor is 1.05
4. The construction date factor as of January 1984 is 1.00
5. All communications, computer, and UPS equipment will be GFE
6. Other requirements include the following:

a. Total equipment load	- 177 kW (within the shelter)
b. Total manpower	- 30 (within the shelter at one time
c. Special features	- 18 in. raised computer floor required
d. Air conditioning system	- underfloor plenum for supply, space above false ceiling for return; water source heat pump with on-site wells for supply and return
e. Lighting	- Standard ADP and office area lighting levels
f. Fire protection	- Halon underfloor, dry pipe water sprinkler ceiling with manual override
g. Power	- commercial for normal operations, rollout scheme for contingency standby, rotary UPS for backup

The costs associated with item 6 above are reflected principally in the mechanical and electrical estimates for the shelters.

Based on these assumptions, construction cost estimates were developed for the buried rectangular cast-in-place concrete construction and for the mounded fibrous concrete dome construction. The total facility costs were

READEX FICHE

$1810k and $1786k, and the corresponding unit costs were $215/sq ft and $207/sq ft, respectively. Detailed cost estimates are provided in Tables G-1 and G-2, respectively.

DCS Case Study Cost Estimate:
Cast-in-Place Concrete Rectangular Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Cast-in-place concrete	CY	1,250	200.	250.0
Reinforcing steel	T	312	1,000.	312.0
Blast doors	LS		57,500.	57.5
Mechanical	LS		113,000.	113.0
Electrical	LS		192,400.	192.4
Drainage	LS		7,500.	7.5
Waterproofing	SY	3,120	5.50	17.2
Excavation	CY	18,180	3.00	54.5
Backfill	CY	8,210	6.00	49.3
Rock rubble	CY	3,730	4.00	14.9
Disposal	CY	9,970	2.50	24.9
Seeding	LS		1,400.	1.4
Unadjusted Facility Cost				$1,094.6k
Location adjustment factor (Belgium)		1.50		
Contingency factor		1.05		
Supervision and administration factor		1.05		
Construction data factor (Jan 84)		1.00		
Adjusted Facility Cost $1,094.6K x 1.50 x 1.05 x 1.05 x 1.00 =				$1,810.2k

DCS Case Study Cost Estimate
Multiple Dome Construction

Item	Unit Measure	Quantity	Unit Cost $	Total Cost $k
Fibrous concrete	CY	435	350.	152.2
Cast-in-place concrete	CY	615	200.	123.0
Reinforcing fibers	LB	114,830	0.50	57.4
Reinforcing steel	T	79	1,000.	79.0
Foam	SF	18,500	6.	111.0
Blast doors	LS		57,500.	57.5
Mechanical	LS		110,500.	110.5
Electrical	LS		214,800.	214.8
Waterproofing	SY	3,250	5.50	17.9
Drainage	LS		11,000.	11.0
Excavation	CY	600	3.00	1.8
Backfill	CY	14,540	6.00	87.3
Rock rubble	CY	4,460	4.00	17.8
Borrow	CY	13,950	2.50	34.9
Seeding	LS		4,200.	4.2
Unadjusted Facility Cost				$1,080.3k
Location adjustment factor (Belgium)		1.50		
Contingency factor		1.05		
Supervision and administration factor		1.05		
Construction data factor (Jan 84)		1.00		
Adjusted Facility Cost $1,080.3k x 1.50 x 1.05 x 1.05 x 1.00 =				$1,786.6k

guidance

DCS FACILITY
STATEMENT OF WORK EXAMPLES (SW)

DCS FACILITY STATEMENT OF WORK EXAMPLES **SW**

Structural Steel Microwave Antenna Tower SW-3

STATEMENT OF WORK
FOR
STRUCTURAL STEEL MICROWAVE ANTENNA TOWER: EXAMPLE

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1.0 SCOPE

This statement of work (SOW) covers the requirement for engineering, furnishing, and erecting a 240-foot self-supporting steel microwave antenna tower The tower may be triangular or rectangular in sections, and components may be tubular, angular, flat bars, or a combination. The finished tower will be complete with:

a. Access ladder equipment with safety climbing device and rest platforms spaced as required by the U.S. Occupational Safety and Health Administration (OSHA).

b. Waveguide ladder support, with ice shield. Provide support for waveguide to span from tower to waveguide ports in building no. S. 520.

c. Antenna platforms (see appendix 1 for number and location).

d. Antenna access catwalks and ladders complete with safety rails.

e. Pipe support and framing for antenna. Antenna side arm structure attachment point.

f. Lightning and grounding protection system with necessary ground rods, straps, etc.

g. Navigational hazard lights.

h. Electrical outlets at antenna platforms.

i. Wire mesh net at lower level of tower to prevent damage from falling ice.

j. Miscellaneous hardware in support of above items.

k. Painting and safety stripping.

l. Tower foundation design is part of this SOW, but soil analysis and site characteristics will be provided by the District Engineer along with the invitation for bid.

2.0 APPLICABLE DOCUMENTS

The following documents form part of this SOW to the extent specified. All documents are U.S. standards, but host-nation equivalent standards may be substituted. When the requirements of the documents listed below conflict with these instructions, the requirements of this SOW shall govern.

2.1 Military Specification

MIL-L-7830	Light, Assembly, Marked Aircraft Obstruction

2.2 Military Standard

MIL-STD-188-124	Grounding, Bonding, Shielding for Common Long-Haul Tactical Communications

2.3 Department of the Army Technical Manual

TM 5-809-10	Seismic Design for Buildings

2.4 American National Standards

EIA RS-222-C	Structural Standards for Steel Antenna Towers and Antenna Supporting Structures
ANSI C2-1981	National Electrical Code
NFPA 70-1981	National Protection Code
NFPA 78-1981	Lightning Protection Code
AISC	Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings
AW D1.1-79	Structural Welding Code
ASTM A-153	Specification for Zinc Coating (Hot Dip) Iron and Steel Hardware
ASTM A-386	Specification for Zinc Coating (Hot Dip) on Assembled Steel Products
ASTM A-123	Specification for Zinc (Hot Galvanized) Coatings on Products Fabricated From Rolled, Pressed, and Forged Steel Shapes
ACI 318-77	Building Code Requirements for Reinforced Concrete

2.5 U.S. Department of Labor, Occupational Safety and Health Administration Publications.

3.0 REQUIREMENTS

3.1 General

The tower shall be self-supporting and made by a recognized steel microwave tower manufacturer. See appendix 1 for coordinates and mounting height of parabolic microwave antenna and elevation of Camp Long, Korea.

3.2 Standards

The tower and its appurtenances will be designed in accordance with the American Institute of Steel Construction (AISC) Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings and with Electronic Industries Association (EIA) standard RS-222-C.

3.3 Design Loads

Wind loading for tower and component parts shall be in accordance with the following formulas:

$$p = 0.004 v^2$$

where p = Wind pressure in pounds per square foot
v = Design/wind velocity in miles per hour.
Wind velocity = 100 miles per hour.

3.3.1. In addition to its own dead load, the additional tower structure (if applicable) shall be designed to sustain dead and live load combinations as follows:

a. Dead load of antenna complete with the integral antenna mounting assembly.

b. Dead load of 2-inch radial solid ice (density 56 pounds per cubic foot) with the applied live load of wind at 100 miles per hour acting simultaneously.

c. Dead load of ladders, platform landings, cable ladder trays, and waveguide. For the waveguide ladder to be installed under this contract, the weight is approximately 10 pounds per linear foot. For waveguide installed by others, the weight is approximately .5 pound per linear foot (assume four waveguide runs).

d. Live load of 100 pounds per square foot on platform landings.

3.3.2. For the tower operational design load, twist and sway shall be designed in accordance with the EIA standard RS-222-C, except that minimum standards shall be based on a wind load of 30 pounds per square foot instead of the 20 pounds required by EIA. Twist and sway shall be limited to 70 degrees at the top of the tower (240 foot point).

Antenna support attachments shall be designed to eliminate any movement with respect to the tower.

4.0 ELECTRICAL REQUIREMENTS

4.1 Accessories

Provide combination weather-proof utility outlets that will be powered from a single-phase source; provide an additional grounding pole at the antenna working level catwalks or platforms. J-boxes, pull boxes, and other devices shall be exterior-type and shall be for use with threaded rigid steel conduit.

4.2 Navigational Hazard Lighting

Navigational hazard lighting shall consist of a hazard beacon, intermediate side obstruction lights, automatic photoelectric control cell, and control-and-alarm system.

4.3 Hazard Beacon

A hazard beacon shall be installed at the top of the tower. This beacon must have two lamps (500 watts each or larger) with long-life design, flashing relay control, load-balance resistor, and red Fresnel-type lens.

4.4 Obstruction Lights

Four obstruction lights shall be installed at the corners of the tower at approximately tower midheight. Lamps will be 100 watts each and designed for long-life. The lens will be the red Fresnel type.

4.5 Control-and-Alarm Cabinet

The control-and-alarm cabinet shall be installed on the ground floor of the communications building and shall contain all electrical equipment needed to control the hazard beacon and obstruction lights.

4.6 Automatic Tower Light Control

A photoelectric cell unit shall be tower-leg-mounted to automatically turn the tower lights on when daylight exposure levels fall to 375 lumens per square meter and off again at a level of 625 lumens per square meter.

4.7 Control Functions

A remote control relay will be provided in the control cabinet to permit connections with remote control circuitry.

4.8 Alarm Functions

The following alarm functions will be provided for audible and visual signals to local security with contacts for future remoting:

a. Normal power failure

b. Beacon lamp failure

c. Obstruction lamp failure

d. Beacon flasher bypass circuit operation

e. Photocell operation failure.

4.9 Surge Protection

Transient voltage suppressors will be provided, when required, to protect electronic components from surges up to 3000 volts.

4.10 Wiring Method

All wiring shall be installed in surface-mounted conduit or cable.

4.11 Lightning Protection Ground System

The contractor shall engineer, furnish, and install a lightning protection ground system for the tower to meet the requirements defined in paragraph 5.1(a) and (c) of MIL-STD-188-124.

5.0 FOUNDATIONS AND ANCHORS

5.1 The District engineer will conduct a detailed soil analysis and provide the results and soil characteristics. Foundations shall be designed in accordance with the provisions of EIA Standard RS-222-C, paragraph 7.2, and the American Concrete Institute's Building Code Requirements for Reinforced Concrete. The design load shall be the specified combination of wind, ice, and dead weight applied to the tower. Seismic design will be determined by zone conditions and in accordance with TM 5-809-10. All anchor bolt sizes and embedments shall be shown on the vendors' design drawings.

6.0 PAINTING

6.1 All structural steel members, railings, platforms, pipes, angles, plates, and hardware shall be hot-dip galvanized in accordance with ASTM 123, 153, and 386.

6.2 The tower will be factory-primed and -painted. The erected tower and support structures shall be painted top to bottom with alternate bands of orange and white of equal width terminating with orange at the top and bottom, in accordance with the International Civil Aernautics Organization (ICAO) and local regulations.

7.0 TOWER ACCESS AND FEATURES

7.1 Climbing Provisions

A ladder (minimum width 15 inches) with a ladder-climbing safety device shall be provided for climbing the full tower height and for servicing the navigational lights. Rest platforms with railings and floor gratings shall be installed at the intervals required by OSHA. A metal grating platform (minimum size 3 by 4 feet) with a safety railing will be provided at each antenna. A grating catwalk (minimum width 18 inches) with a safety handrail will be provided to run between the ladder and the antenna platform. Ladders, railings, gratings, antenna supports, anchors, and clips shall be galvanized and shop-fabricated and -assembled.

7.2 Ladder Climbing Safety Device

The device shall provide a sleeve to slide up and down on a notched rail. The sleeve shall contain a locking panel mechanism that automatically engages the locks into the rail if sudden weight is applied.

7.3 Railings

Pipes for posts and railings shall be 1.5-inch standard weight galvanized steel. Railings and post intersections shall be welded. Post base fittings shall be standard flange-type for bolting to the tower frame.

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